

2010 Subaru Outback R

2010 ENGINE Mechanical (H6DO) - Legacy and Outback

2010 ENGINE

Mechanical (H6DO) - Legacy and Outback

GENERAL DESCRIPTION

SPECIFICATION

GENERAL SPECIFICATION CHART

Engine	Model		3.6 L	
	Cylinder arrangement		Horizontally opposed, liquid cooled, 6-cylinder, 4-stroke gasoline engine	
	Valve system mechanism		Chain driven, double overhead camshaft, 4-valve/cylinder	
	Bore x Stroke	mm (in)	92 x 91 (3.622 x 3.583)	
	Displacement	cm ³ (cu in)	3,629 (221)	
	Compression ratio		10.5	
	Compression pressure (350 RPM and fully open throttle)	KPa (Kgf/cm ² , psi)	Standard	1,275 - 1,471 (13.0 - 15.0, 185 - 213)
	Number of piston rings		Pressure ring: 2, Oil ring: 1	
	Intake valve timing	Open	Max. retard	ATDC 10°
			Min. advance	BTDC 40°
		Close	Max. retard	ABDC 74°
			Min. advance	ABDC 24°
	Exhaust valve timing	Open	Max. retard	BBDC 4°
			Min. advance	BBDC 44°
		Close	Max. retard	ATDC 44°
			Min. advance	ATDC 4°
	Valve clearance	mm (in)	Intake	0.20 ⁺⁰⁰⁴ _{-0.06} (0.0079 ⁺⁰⁰⁰¹⁶ _{-0.0024})
			Exhaust	0.35±0.05 (0.0138±0.0020)
	Idle speed ["P" or "N" range]	RPM	No load	Standard 700±100
			A/C ON	Standard 700 - 910±100
	Ignition order		1 --> 6 --> 3 --> 2 --> 5 --> 4	

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Ignition timing

BTDC/RPM

Standard

15°±8°/700

NOTE: OS: Oversize
US: Undersize

CAMSHAFT SPECIFICATION CHART

Camshaft	Bending limit		mm (in)		0.020 (0.00079)	
	Cam lobe height	mm (in)	Intake	Standard	45.90 - 46.00 (1.8071 - 1.8110)	
			Exhaust	Standard	44.65 - 44.75 (1.7579 - 1.7618)	
	Cam base circle diameter	mm (in)	Intake	Standard	36.00 (1.4173)	
			Exhaust	Standard	36.00 (1.4173)	
	Journal O.D.	mm (in)	Front	Standard	37.946 - 37.963 (1.4939 - 1.4946)	
			Except for front	Standard	25.946 - 25.963 (1.0215 - 1.0222)	
	Oil clearance		mm (in)	Standard	0.037 - 0.072 (0.0015 - 0.0028)	
	Thrust clearance	mm (in)	Intake	Standard	0.075 - 0.135 (0.0030 - 0.0053)	
Exhaust			Standard	0.075 - 0.135 (0.0030 - 0.0053)		
Cylinder head	Warping limit (Mating surface with cylinder block)			mm (in)	0.020 (0.0008)	
	Standard height			mm (in)	124±0.05 (4.88±0.0020)	
Valve seat	Seating angle between valve and valve seat				90°	
	Contacting width of valve and valve seat	mm (in)	Intake	Standard	1.0 (0.039)	
			Exhaust	Standard	1.5 (0.059)	
Valve guide	Clearance between the valve guide and valve stem	mm (in)	Intake	Standard	0.030 - 0.057 (0.0012 - 0.0022)	
			Exhaust	Standard	0.040 - 0.067 (0.0016 - 0.0026)	
	Inside diameter			mm (in)	5.500 - 5.512 (0.2165 - 0.2170)	
	Valve stem outer diameter	mm (in)	Intake		5.455 - 5.470 (0.2148 - 0.2154)	
			Exhaust		5.445 - 5.460 (0.2144 - 0.2150)	
	Valve guide protrusion amount		Intake	mm (in)		8.6 - 9.0 (0.3386 - 0.3543)
			Exhaust		mm (in)	10.7-11.1 (0.4213 - 0.4370)
	Head edge thickness	mm	Intake	Standard	1.0 (0.039)	

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Valve	(in)Exhaust		Standard	1.2 (0.047)
	Overall length	mm (in)	Intake	103.5 (4.075)
			Exhaust	103.2 (4.063)
Valve spring	Free length	mm (in)	Intake	49.06 (1.9315)
			Exhaust	49.06 (1.9315)
	Tension/spring height	N (kgf, lb)/mm (in)	Set	182 - 210 (18.6 - 21.4,40.9 - 47.2)/31.0 (1.220)
			Lift	316 - 350 (32.2 - 35.7, 71.0 - 78.7)/21.0 (0.827)
	Squareness			2.5°, 2.1 mm (0.083 in)
Valve lifter	Outer diameter	mm (in)	Standard	32.959 - 32.975 (1.2976 - 1.2982)
	Inner diameter of valve lifter mating surface	mm (in)	Standard	32.994 - 33.016 (1.2990 - 1.2998)
	Clearance between valve lifter and valve lifter mating surface	mm (in)	Standard	0.019 - 0.057 (0.0007 - 0.0022)
Cylinder block	Warping limit (Mating surface with cylinder head)		mm (in)	0.020 (0.0008)
	Standard height		mm (in)	202 (7.95)
	Taper	mm (in)	Standard	0.030 (0.0012)
	Out-of-roundness	mm (in)	Standard	0.010 (0.0004)
	Cylinder to piston clearance at 20°C (68°F):	mm (m)	Standard	-0.010 - 0.010 (-0.0004 - 0.0004)
	Cylinder inner diameter boring limit (diameter)		mm (in)	92.515 (3.6717)
Piston	Piston grade point		mm (in)	37.3 (1.4685)
	Outer diameter	Standard	A	92.005 - 92.015 (3.6222 - 3.6226)
			B	91.995 - 92.005 (3.6218 - 3.6222)
		0.25 (0.0098) OS	92.245 - 92.265 (3.6317 - 3.6325)	
			92.495 - 92.515 (3.6415 - 3.6423)	
	Inner diameter of piston pin hole		mm (in)	Standard
	Degree of fit			Piston pin must be fitted into position with thumb

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Piston pin					at 20°C (68°F).		
	Outer diameter			mm (in)	Standard	21.994 - 22.000 (0.8659 - 0.8661)	
	Clearance between piston and piston pin			mm (in)	Standard	0.004 - 0.008 (0.0002 - 0.0003)	
Piston ring	Piston ring gap		mm (in)	Top ring		Standard	0.20 - 0.25 (0.0079 - 0.0098)
				Second ring		Standard	0.40 - 0.50 (0.0157 - 0.0197)
				Oil ring		Standard	0.20 - 0.50 (0.0079 - 0.0197)
	Clearance between piston ring and piston ring groove		mm (in)	Top ring		Standard	0.040 - 0.080 (0.0016 - 0.0031)
				Second ring		Standard	0.030 - 0.070 (0.0012 - 0.0028)
				Oil ring		Standard	0.065 - 0.165 (0.0026 - 0.0065)
Connecting rod and connecting rod bearing	Bend or twist per 100 mm (3.94 in) in length			mm (in)	Service limit	0.10 (0.0039 in)	
	Thrust clearance			mm (in)	Standard	0.070 - 0.330 (0.0028 - 0.0130)	
	Oil clearance			mm (in)	Standard	0.016 - 0.043 (0.0006 - 0.0017)	
	Bearing size (Thickness at center)		mm (in)	Standard		1.489 - 1.505 (0.0586 - 0.0593)	
				0.03 (0.0012) US		1.507 - 1.515 (0.0593 - 0.0596)	
				0.05 (0.0020) US		1.517 - 1.525 (0.0597 - 0.0600)	
				0.25 (0.0098) US		1.617 - 1.625 (0.0637 - 0.0640)	
Bushing of small end	Clearance between piston pin and bushing			mm (in)	Standard	0 - 0.022 (0 - 0.0009)	
	Bending limit				mm (in)	0.035 (0.0014)	
	Crank pin		Out-of-roundness		mm (in)	0.005 (0.0002)	
			Cylindricity		mm (in)	0.006 (0.0002)	
			Grinding limit	mm (in)	51.734 (2.0368)		
	Crank journal		Out-of-roundness		mm (in)	0.005 (0.0002)	
			Cylindricity		mm (in)	0.006 (0.0002)	
			Grinding limit	mm (in)	63.742 (2.5095)		
				Standard		51.976 - 52.000 (2.0463 - 2.0472)	

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Crankshaft and crankshaft bearing	Crank pin outer diameter mm (in)		0.03 (0.0012) US	51.954 - 51.970 (2.0454 - 2.0461)
			0.05 (0.0020) US	51.934 - 51.950 (2.0446 - 2.0453)
			0.25 (0.0098) US	51.734 - 51.750 (2.0368 - 2.0374)
	Crank journal outer diameter mm (in)	#1, #3, #5, #7	Standard	63.992 - 64.016 (2.5194 - 2.5203)
			0.03 (0.0012) US	63.962 - 63.978 (2.5182 - 2.5188)
			0.05 (0.0020) US	63.942 - 63.958 (2.5174 - 2.5180)
			0.25 (0.0098) US	63.742 - 63.758 (2.5095 - 2.5102)
		#2, #4, #6	Standard	63.992 - 64.016 (2.5194 - 2.5203)
			0.03 (0.0012) US	63.962 - 63.978 (2.5182 - 2.5188)
			0.05 (0.0020) US	63.942 - 63.958 (2.5174 - 2.5180)
			0.25 (0.0098) US	63.742 - 63.758 (2.5095 - 2.5102)
	Bearing size (Thickness at center) mm (in)	#1, #3, #5	Standard	1.996 - 2.013 (0.0786 - 0.0793)
			0.03 (0.0012) US	2.011 - 2.014 (0.0792 - 0.0793)
			0.05 (0.0020) US	2.021 - 2.024 (0.0796 - 0.0797)
			0.25 (0.0098) US	2.121 - 2.124 (0.0835 - 0.0836)
		#2, #4, #6	Standard	1.996 - 2.013 (0.0786 - 0.0793)
			0.03 (0.0012) US	2.015 - 2.018 (0.0793 - 0.0794)
			0.05 (0.0020) US	2.025 - 2.028 (0.0797 - 0.0798)
			0.25 (0.0098) US	2.125 - 2.128 (0.0837 - 0.0838)
		#7	Standard	1.992 - 2.009 (0.0784 - 0.0791)
			0.03 (0.0012) US	2.011 - 2.014 (0.0792 - 0.0793)
			0.05 (0.0020) US	2.021 - 2.024 (0.0796 - 0.0797)

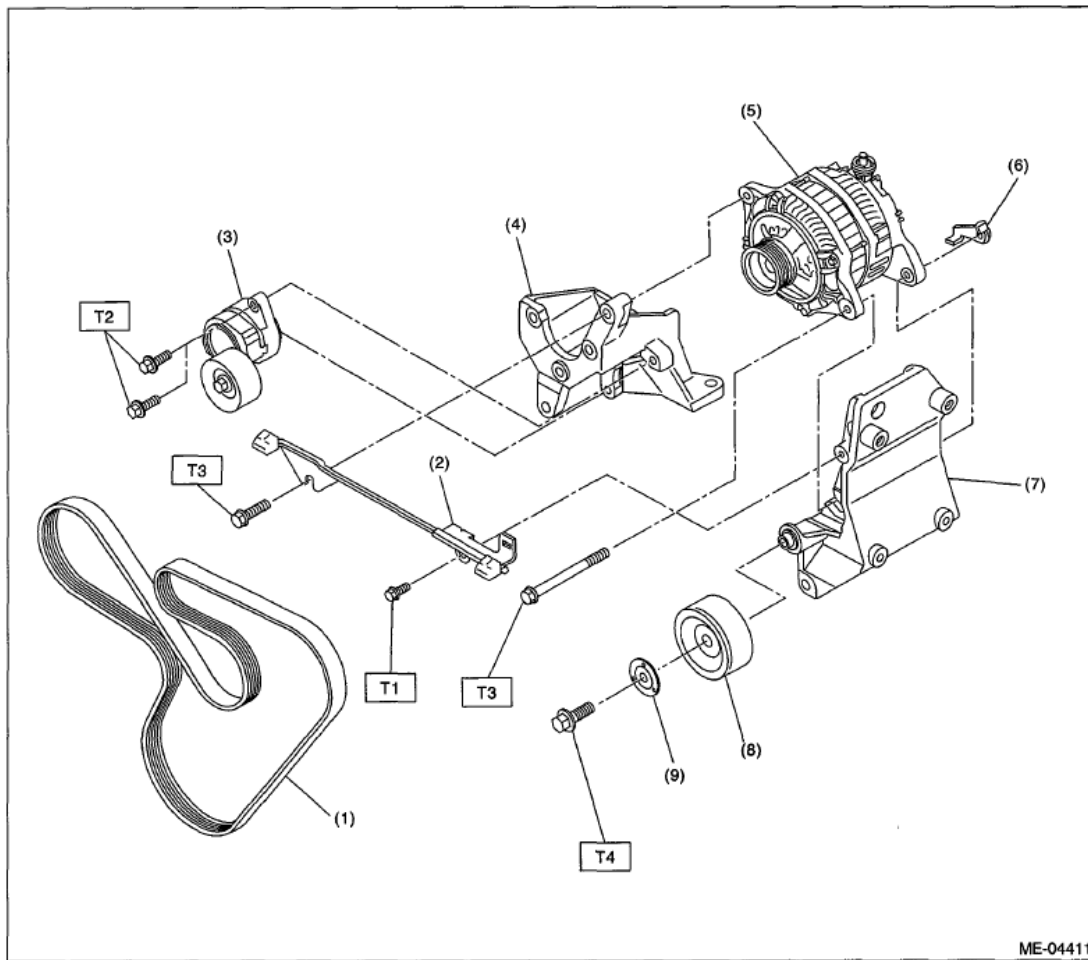
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			0.25 (0.0098) US	2.121 - 2.124 (0.0835 - 0.0836)
Thrust clearance	mm (in)	Standard		0.030 - 0.115 (0.0012 - 0.0045)
Oil clearance	mm (in)	Standard		0.010 - 0.030 (0.0004 - 0.0012)

COMPONENT

V-BELT



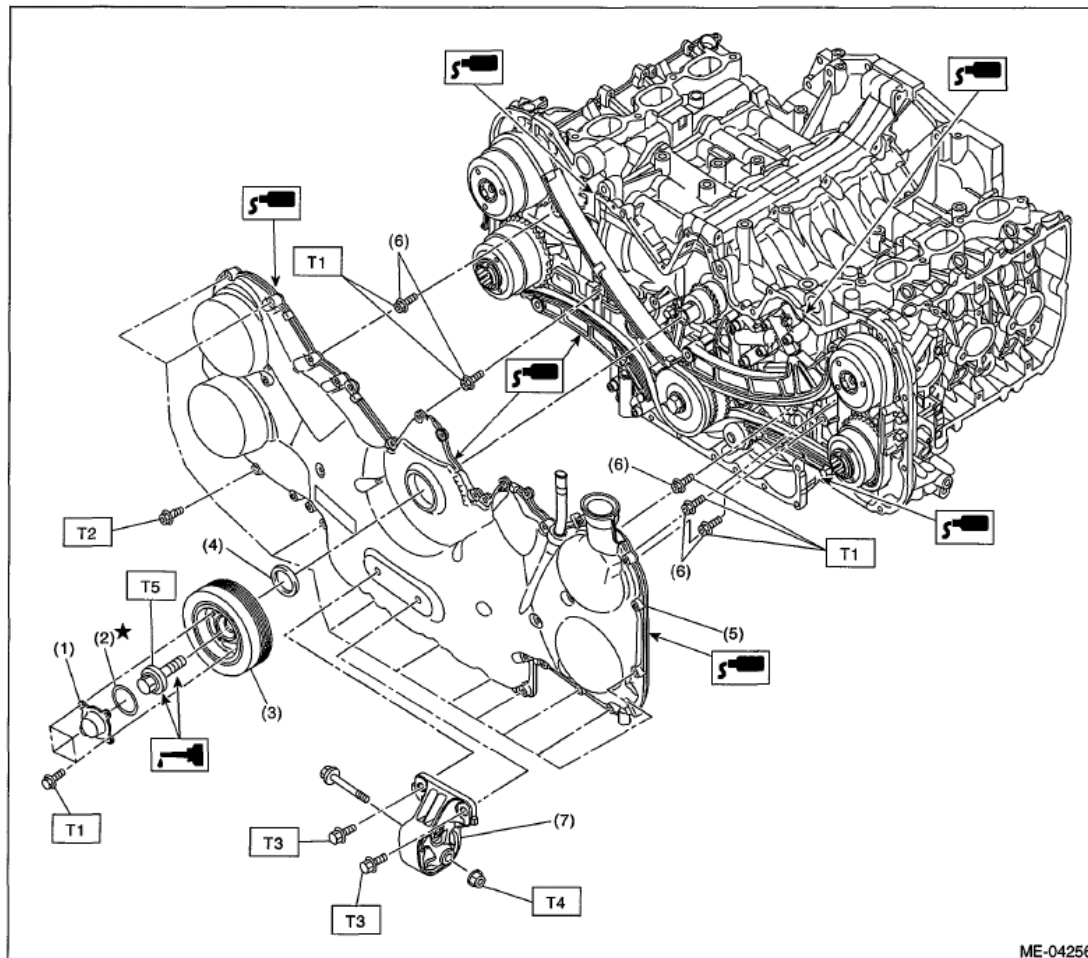
- | | |
|---------------------------------|-------------------------|
| (1) V-belt | (6) Generator plate |
| (2) Collector cover bracket | (7) A/C compressor stay |
| (3) Belt tensioner ASSY | (8) Idler pulley |
| (4) Power steering pump bracket | (9) Idler pulley cover |
| (5) Generator | |

Tightening torque: N-m (kgf-m, ft-lb)

- | | |
|------------|-----------------------|
| T1: | 6.4 (0.7, 4.7) |
| T2: | 20 (2.0, 14.8) |
| T3: | 25 (2.5, 18.4) |
| T4: | 33 (3.4, 24.3) |

Fig. 1: Exploded View Of V-Belt With Torque Specifications
Courtesy of SUBARU OF AMERICA, INC.

CHAIN COVER



- (1) Crank pulley cover
- (2) O-ring
- (3) Crank pulley
- (4) Oil seal
- (5) Chain cover
- (6) Bolt

- (7) Front mount

Tightening torque: N-m (kgf-m, ft-lb)

T1: 6.4 (0.7, 4.7)

T2: 10 (1.0, 7.4)

T3: 25 (2.5, 18.4)

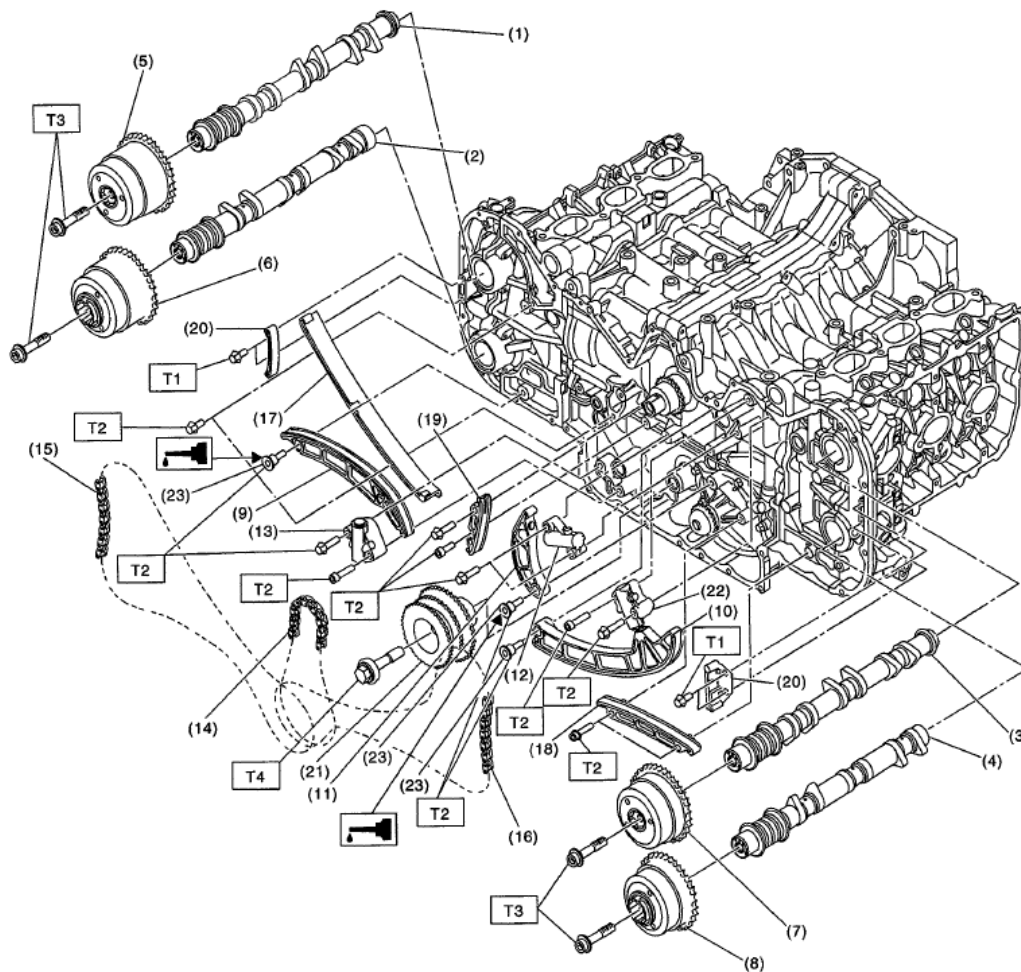
T4: 45 (4.6, 33.2)

T5: 195 (19.9, 143.8)

Fig. 2: Exploded View Of Chain Cover With Torque Specifications

Courtesy of SUBARU OF AMERICA, INC.

TIMING CHAIN



ME-04428

- | | | |
|---------------------------------|-----------------------------------|----------------------------------|
| (1) Intake camshaft (RH) | (11) Chain tensioner lever (Main) | (21) Idler sprocket |
| (2) Exhaust camshaft (RH) | (12) Chain tensioner (Main) | (22) Chain tensioner (LH) |
| (3) Intake camshaft (LH) | (13) Chain tensioner (RH) | (23) Chain tensioner lever shaft |
| (4) Exhaust camshaft (LH) | (14) Timing chain (Main) | |
| (5) Intake cam sprocket (RH) | (15) Timing chain (RH) | |
| (6) Exhaust cam sprocket (RH) | (16) Timing chain (LH) | |
| (7) Intake cam sprocket (LH) | (17) Chain guide (RH) | |
| (8) Exhaust cam sprocket (LH) | (18) Chain guide (LH) | |
| (9) Chain tensioner lever (RH) | (19) Chain guide (Main) | |
| (10) Chain tensioner lever (LH) | (20) Chain guide (Between cams) | |

Tightening torque: N·m (kgf-m, ft-lb)

T1: 6.4 (0.7, 4.7)

T2: 16 (1.6, 11.8)

T3: <Ref. to ME(H6DO)-77, Cam Sprocket.>

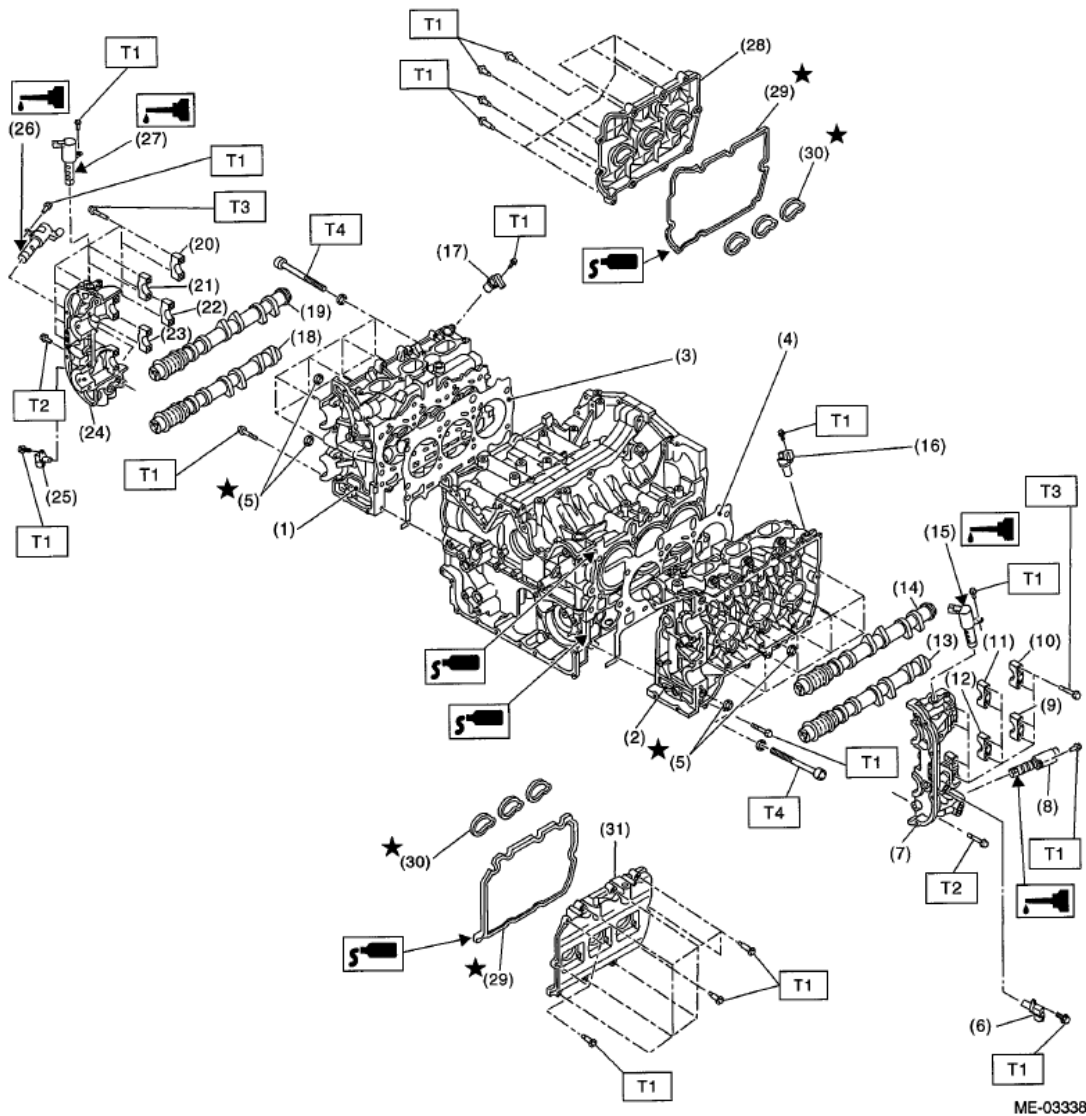
T4: 120 (12.2, 88.5)

Fig. 3: Exploded View Of Timing Chain With Torque Specifications
Courtesy of SUBARU OF AMERICA, INC.

CYLINDER HEAD AND CAMSHAFT

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ME-03338

(1) Cylinder head (RH)	(14) Intake camshaft (LH)	(27) Intake oil flow control solenoid valve (RH)
(2) Cylinder head (LH)	(15) Intake oil flow control solenoid valve (LH)	(28) Rocker cover (RH)
(3) Cylinder head gasket (RH)	(16) Intake camshaft position sensor (LH)	(29) Gasket
(4) Cylinder head gasket (LH)	(17) Intake camshaft position sensor (RH)	(30) Gasket
(5) O-ring	(18) Exhaust camshaft (RH)	(31) Rocker cover (LH)
(6) Exhaust camshaft position sensor (LH)	(19) Intake camshaft (RH)	
(7) Front camshaft cap (LH)	(20) Intake camshaft cap (Rear RH)	
(8) Exhaust oil flow control solenoid valve (LH)	(21) Intake camshaft cap (Center RH)	
(9) Exhaust camshaft cap (Rear LH)	(22) Exhaust camshaft cap (Rear RH)	
(10) Intake camshaft cap (Rear LH)	(23) Exhaust camshaft cap (Center RH)	
(11) Intake camshaft cap (Center LH)	(24) Front camshaft cap (RH)	
(12) Exhaust camshaft cap (Center)	(25) Exhaust camshaft position sensor	

Tightening torque: N·m (kgf-m, ft-lb)

T1: 6.4 (0.7, 4.7)

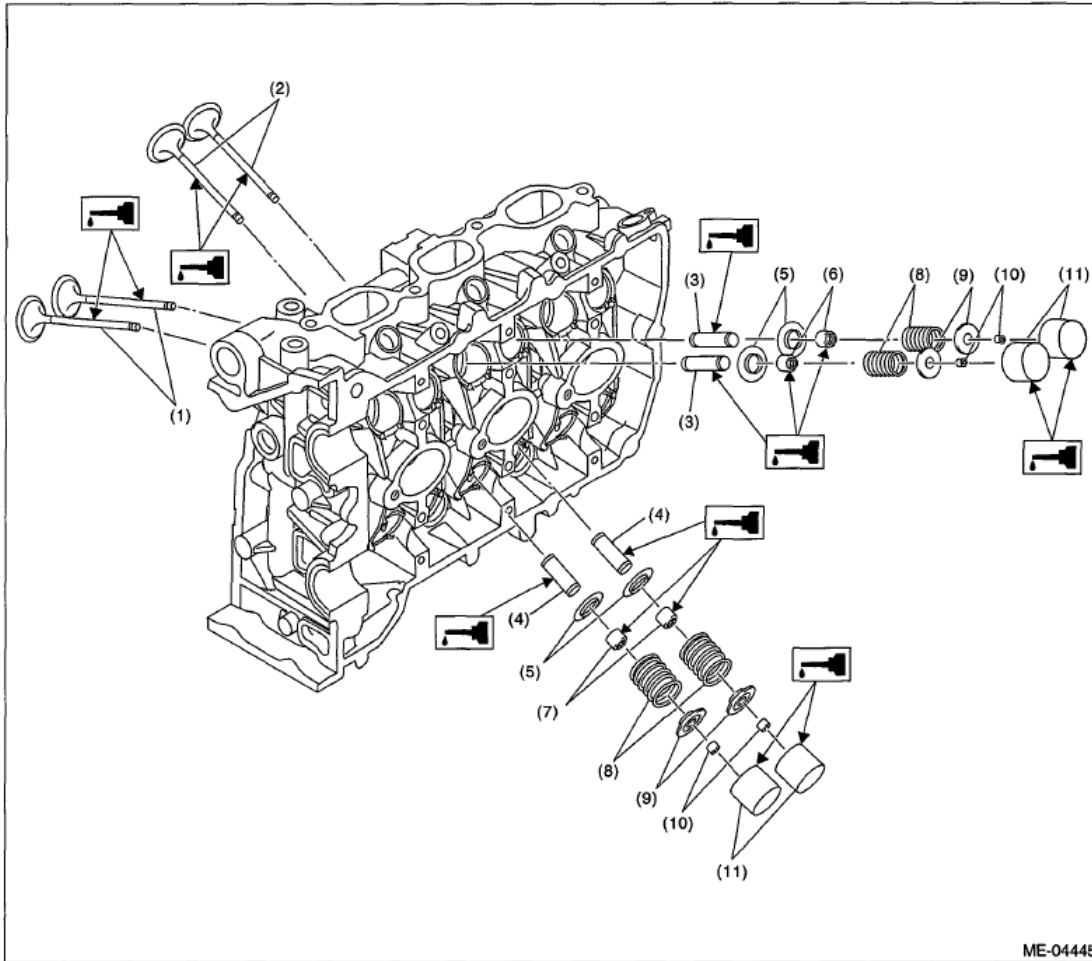
T2: 9.75 (1.0, 7.2)

T3: 16 (1.6, 11.8)

T4: <Ref. to ME(H6DO)-86, Cylinder Head.>

Fig. 4: Exploded View Of Cylinder Head And Camshaft With Torque Specifications
Courtesy of SUBARU OF AMERICA, INC.

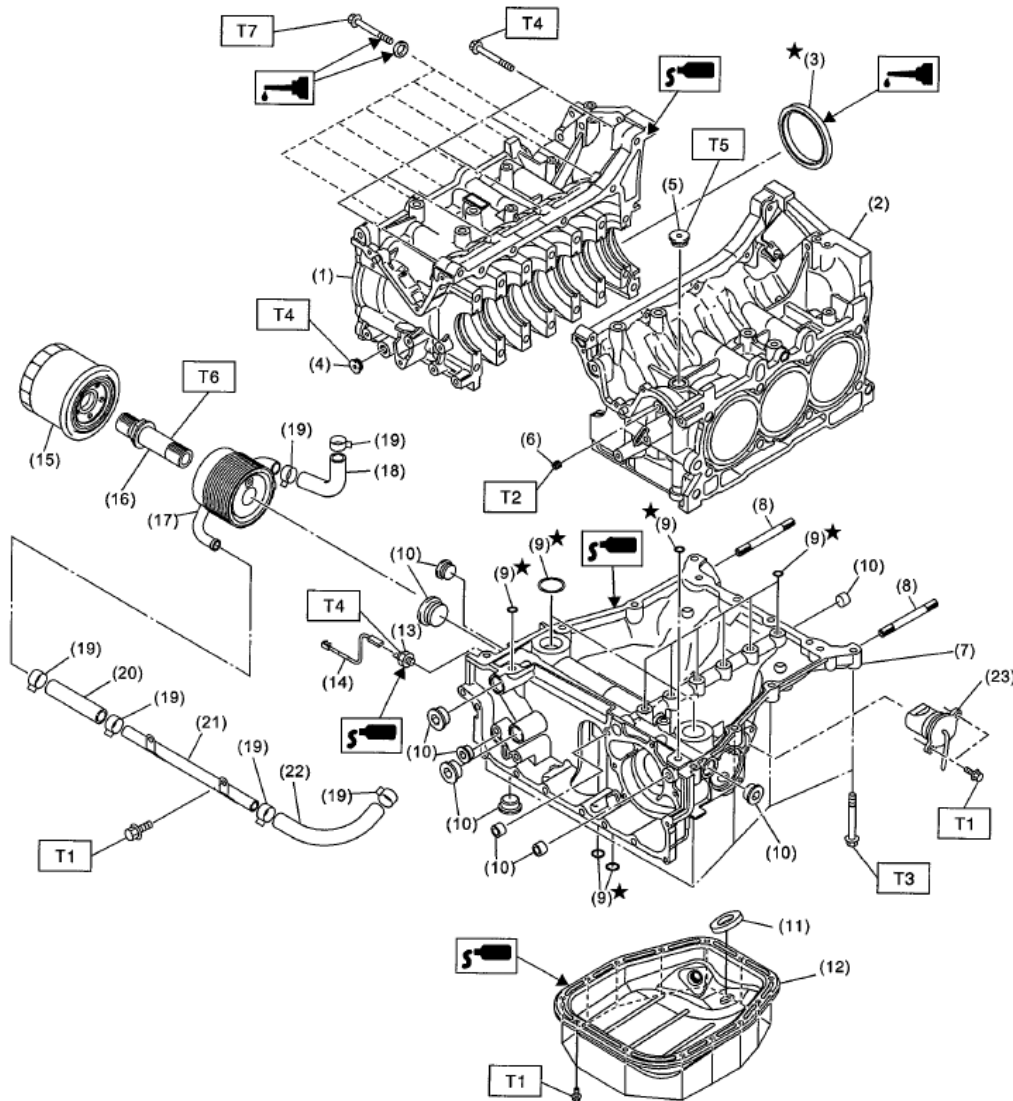
CYLINDER HEAD AND VALVE ASSEMBLY



- | | | |
|---------------------------|-------------------------|---------------------------|
| (1) Intake valve | (5) Valve spring seat | (9) Valve spring retainer |
| (2) Exhaust valve | (6) Stem seal (Intake) | (10) Valve collet |
| (3) Valve guide (Intake) | (7) Stem seal (Exhaust) | (11) Valve lifter |
| (4) Valve guide (Exhaust) | (8) Valve spring | |

Fig. 5: Exploded View Of Cylinder Head And Valve Assembly
Courtesy of SUBARU OF AMERICA, INC.

CYLINDER BLOCK

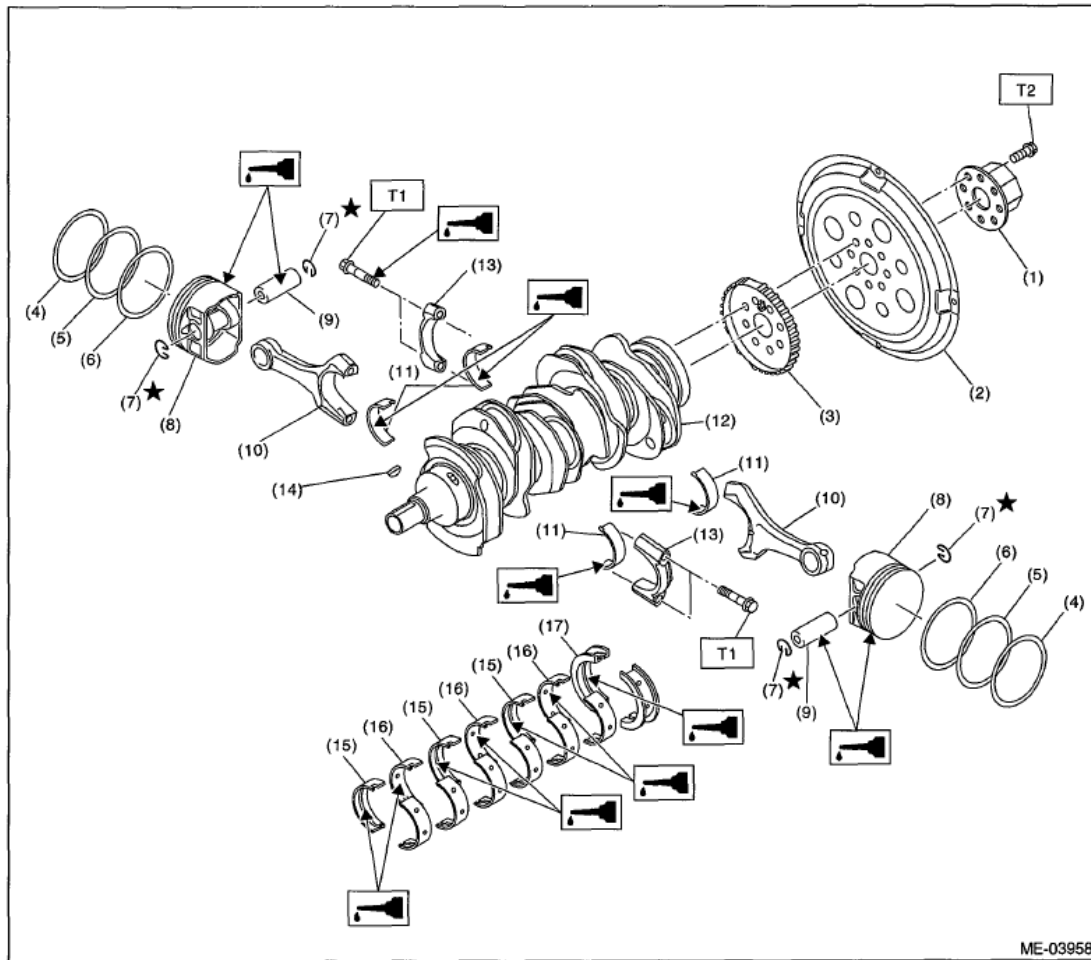


ME-04494

(1) Cylinder block (RH)	(12) Oil pan lower	(23) Oil level switch
(2) Cylinder block (LH)	(13) Oil pressure switch	
(3) Oil seal	(14) Oil pressure switch harness	Tightening torque:N·m (kgf-m, ft-lb)
(4) Plug	(15) Oil filter	T1: 6.4 (0.7, 4.7)
(5) Plug	(16) Oil cooler connector	T2: 17 (1.7, 12.5)
(6) Orifice	(17) Oil cooler	T3: 18 (1.8, 13.3)
(7) Oil pan upper	(18) Hose	T4: 25 (2.5, 18.4)
(8) Stud bolt	(19) Clamp	T5: 37 (3.8, 27.3)
(9) O-ring	(20) Hose	T6: 54 (5.5, 39.8)
(10) Plug	(21) Oil cooler pipe	T7: <Ref. to ME(H6DO)-96, Cylinder Block.>
(11) Magnet	(22) Hose	

Fig. 6: Exploded View Of Cylinder Block With Torque Specifications
 Courtesy of SUBARU OF AMERICA, INC.

CRANKSHAFT AND PISTON



ME-03958

- | | | |
|-----------------------------|------------------------------------|------------------------------------|
| (1) Reinforcement | (9) Piston pin | (16) Crankshaft bearing #2, #4, #6 |
| (2) Drive plate | (10) Connecting rod | (17) Crankshaft bearing #7 |
| (3) Crankshaft sensor plate | (11) Connecting rod bearing | |
| (4) Top ring | (12) Crankshaft | |
| (5) Second ring | (13) Connecting rod cap | |
| (6) Oil ring | (14) Woodruff key | |
| (7) Snap ring | (15) Crankshaft bearing #1, #3, #5 | |
| (8) Piston | | |

Tightening torque: N·m (kgf-m, ft-lb)

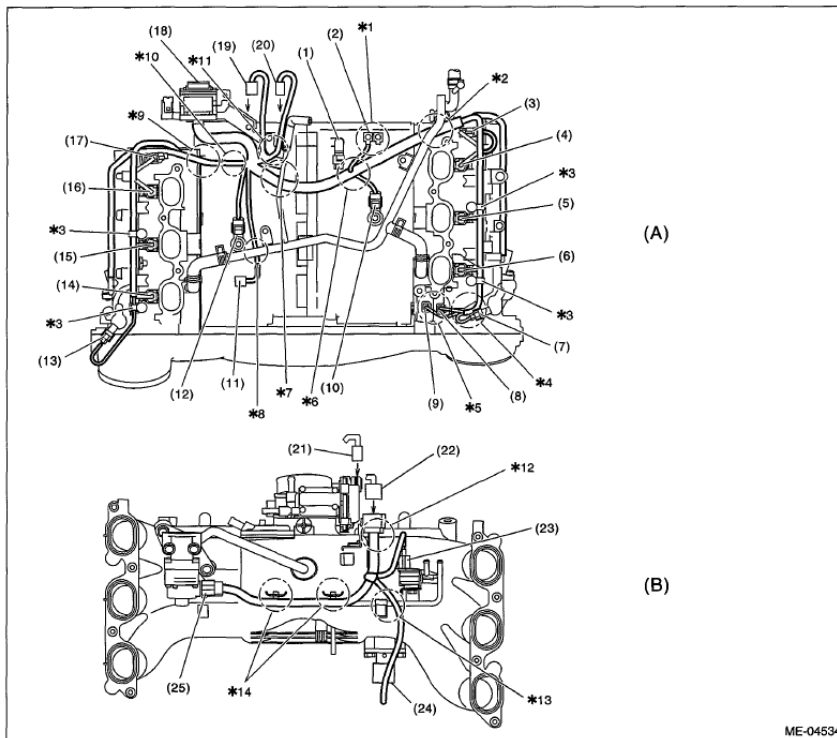
T1: 60 (6.1, 44.3)

T2: <Ref. to 5AT-65, INSTALLATION, Drive Plate.>

Fig. 7: Exploded View Of Crankshaft And Piston With Torque Specifications
Courtesy of SUBARU OF AMERICA, INC.

ENGINE HARNESS

Engine harness assembly diagram 1

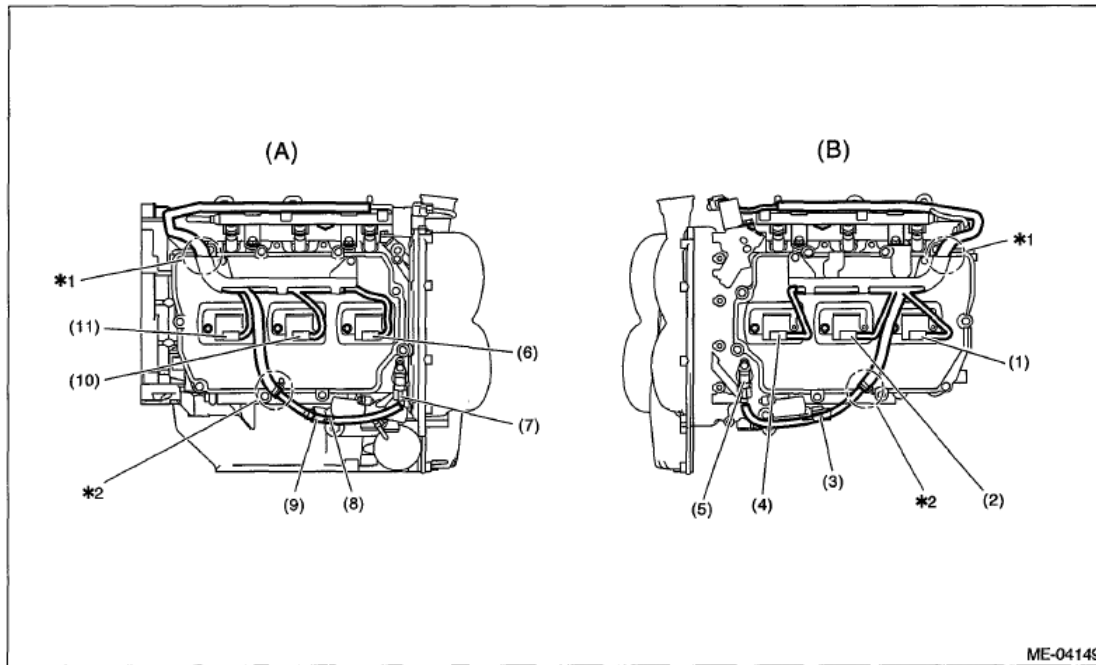


- | | | |
|---|--|--|
| (A) Cylinder block upper face | (B) Intake manifold back surface | |
| (1) Crankshaft position sensor connector | (10) Knock sensor LH connector | (19) Upper/lower connection connector (To intake manifold) |
| (2) Engine ground | (11) Power steering switch connector | (20) Electronic throttle control connector (To intake manifold) |
| (3) Intake camshaft position sensor LH connector | (12) Knock sensor RH connector | (21) Electronic throttle control connector (From upper part of the cylinder block) |
| (4) #6 injector connector | (13) Intake oil flow control solenoid valve RH connector | (22) Upper/lower connection connector (From upper part of the cylinder block) |
| (5) #4 injector connector | (14) #1 injector connector | (23) Purge control solenoid valve connector |
| (6) #2 injector connector | (15) #3 injector connector | (24) Manifold absolute pressure sensor connector |
| (7) Intake oil flow control solenoid valve LH connector | (16) #5 injector connector | (25) EGR valve connector |
| (8) Oil temperature sensor connector | (17) Intake camshaft position sensor RH connector | |
| (9) Engine coolant temperature sensor connector | (18) Engine harness docking connector | |

- *1: Install so that engine ground terminals face the rear side of vehicle.
 *2: Route under the heater pipe.
 *3: Attach the engine harness fixing clip to the fuel pipe stay.
 *4: Route from the cutout portion on the fuel pipe protector LH.
 *5: Be careful not to mix up the connectors of oil temperature sensor and engine coolant temperature sensor.
 *6: Route between crankshaft position sensor and knock sensor LH.
 *7: Route under the heater pipe.
 *8: Route under the heater pipe.
 *9: Route under the fuel pipe.
 *10: Attach the engine harness fixing clip to the fixing boss on the cylinder block.
 *11: Route over the heater pipe stay.
 *12: Securely install the engine harness fixing stay.
 *13: Route outside the fuel pipe.
 *14: Attach the engine harness fixing clip to the fixing stay on the intake manifold.

Fig. 8: Identifying Engine Harness Assembly (1 Of 2)
 Courtesy of SUBARU OF AMERICA, INC.

Engine harness assembly diagram 2



(A) Right side of the engine

(B) Left side of the engine

- | | | |
|--|---|--|
| (1) #6 ignition coil connector | (5) Exhaust camshaft position sensor LH connector | (9) Exhaust oil flow control valve solenoid RH connector |
| (2) #4 ignition coil connector | (6) #1 injector connector | (10) #3 ignition coil connector |
| (3) Exhaust oil flow control valve solenoid LH connector | (7) Exhaust camshaft position sensor RH connector | (11) #5 ignition coil connector |
| (4) #2 ignition coil connector | (8) Oil pressure switch connector | |

*1: Align the engine harness stay end with the end of engine harness identification tape.

*2: Attach the engine harness fixing clip to the fixing boss on the rocker cover.

Fig. 9: Identifying Engine Harness Assembly (2 Of 2)

Courtesy of SUBARU OF AMERICA, INC.

CAUTION

- Wear appropriate work clothing, including a cap, protective goggles and protective shoes when performing any work.
- Remove contamination including dirt and corrosion before removal, installation or disassembly.
- Keep the disassembled parts in order and protect them from dust and dirt.
- Before removal, installation or disassembly, be sure to clarify the failure. Avoid unnecessary removal, installation, disassembly and replacement.
- Vehicle components are extremely hot after driving. Be wary of receiving burns from heated parts.
- Be sure to tighten fasteners including bolts and nuts to the specified torque.
- Place shop jacks or rigid racks at the specified points.
- Before disconnecting connectors of sensors or units, be sure to disconnect the ground cable from battery.
- All parts should be thoroughly cleaned, paying special attention to engine oil passages, pistons and bearings.

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- Before applying liquid gasket, completely remove the old liquid gasket and degrease it.
- Rotating parts and sliding parts such as piston, bearing and gear should be coated with oil prior to assembly.
- All removed parts, if to be reused, should be reinstalled in the original positions and directions.
- Bolts, nuts and washers should be replaced with new parts as required.
- Even if necessary inspections have been made in advance, proceed with assembly work while making re-checks.
- Remove or install the engine in an area where chain hoists, lifting devices, etc. are available for ready use.
- Be sure not to damage coated surfaces of body panels with tools, or not to stain seats and windows with coolant or oil. Place a cover over fender, as required, for protection.
- Prior to starting work, prepare the following:

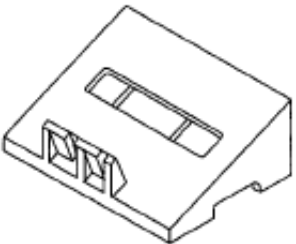
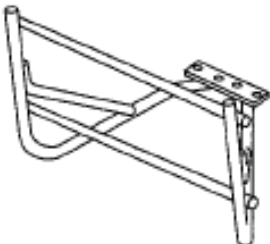
Service tools, clean cloth, containers to catch coolant and oil, wire ropes, chain hoist, transmission jacks, etc.

- Lift up or lower the vehicle when necessary. Make sure to support the correct positions.

PREPARATION TOOL

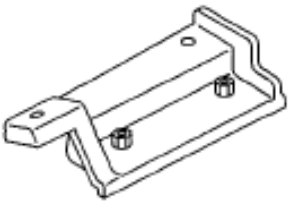
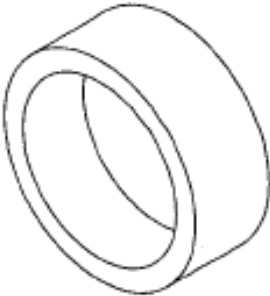
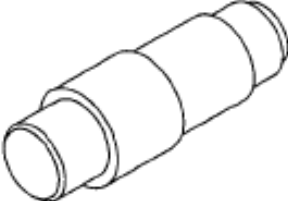
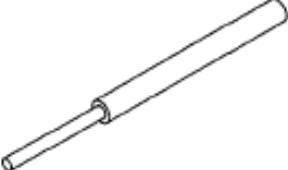
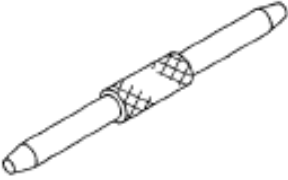
SPECIAL TOOL

SPECIAL TOOL DESCRIPTION CHART

ILLUSTRATION	TOOL NUMBER	DESCRIPTION	REMARKS
 ST18250AA010	18250AA010	CYLINDER HEAD TABLE	• Used for replacing valve guides. • Used for removing and installing valve spring.
 ST18232AA000	18232AA000	ENGINE STAND	Used for disassembling and assembling engine.

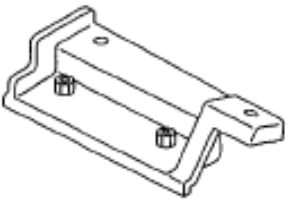
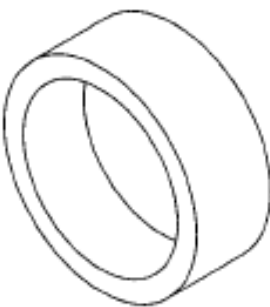
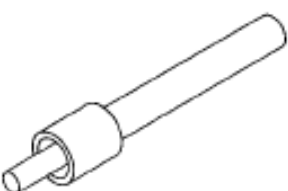
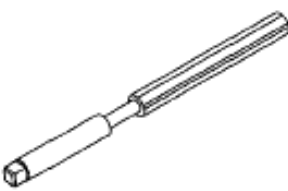
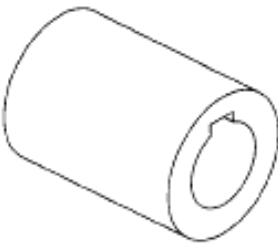
2010 Subaru Outback R

2010 ENGINE Mechanical (H6DO) - Legacy and Outback

 ST-498457000	498497100	CRANKSHAFT STOPPER	Used for stopping rotation of drive plate when removing/tightening crank pulley bolt.
 ST-398744300	398744300	PISTON GUIDE	Used for installing piston in cylinder.
 ST18350AA000	499585500	VALVE OIL SEAL GUIDE	Used for press-fitting of intake and exhaust valve guide oil seals.
 ST-499765700	18350AA000	CONNECTING ROD BUSHING REMOVER AND INSTALLER	Used for removing and installing connecting rod bushing.
 ST-499017100	499977500	CAM SPROCKET WRENCH	Used for removing and installing cam sprocket.

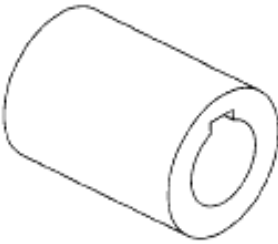
2010 Subaru Outback R

2010 ENGINE Mechanical (H6DO) - Legacy and Outback

 ST-498457100	499587200	CRANKSHAFT OIL SEAL INSTALLER	• Used for installing crankshaft oil seal. • Used together with CRANKSHAFT OIL SEAL GUIDE (499597100).
 ST-498747300	499597100	CRANKSHAFT OIL SEAL GUIDE	• Used for installing crankshaft oil seal. • Used together with CRANKSHAFT OIL SEAL INSTALLER (499587200).
 ST-498857100	499718000	VALVE SPRING REMOVER	Used for removing and installing valve spring.
 ST-499765900	499765700	VALVE GUIDE REMOVER	Used for removing valve guides.
 ST18252AA000	499765900	VALVE GUIDE REAMER	Used for reaming valve guides.

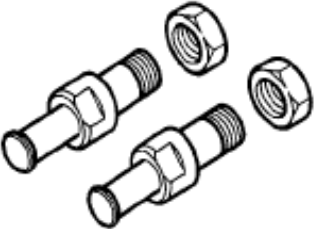
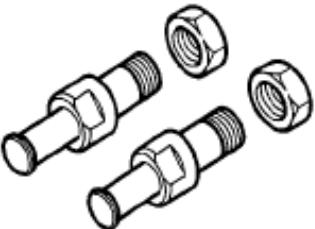
2010 Subaru Outback R

2010 ENGINE Mechanical (H6DO) - Legacy and Outback

 ST18252AA000	18252AA000	CRANKSHAFT SOCKET	Used for rotating crankshaft.
 ST1B022XU0	1B022XU0	SUBARU SELECT MONITOR III KIT	Used for troubleshooting the electrical system.
 ST18231AA010	498277200	STOPPER SET	Used for installing automatic transmission assembly to engine.
 ST-499585700	499585700	OIL SEAL GUIDE	Used for installing the chain cover oil seal.
	18251AA050	VALVE GUIDE ADJUSTER	Used for installing valve guides on intake side.

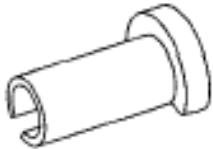
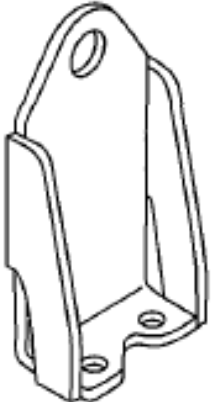
2010 Subaru Outback R

2010 ENGINE Mechanical (H6DO) - Legacy and Outback

 ST18251AA060			
 ST18355AA000	18251AA060	VALVE GUIDE ADJUSTER	Used for installing valve guides on exhaust side.
 ST18334AA000	18355AA000	PULLEY WRENCH	• Used for stopping rotation of crank pulley when removing and installing crank pulley bolt. • Used for stopping rotation of idler sprocket when removing and installing idler sprocket bolt. • Used together with PULLEY WRENCH PIN SET (18334AA000).
 ST18334AA000	18334AA000	PULLEY WRENCH PIN SET	• Used for stopping rotation of crank pulley when removing and installing crank pulley bolt. • Used for stopping rotation of idler sprocket when removing and installing idler sprocket bolt. • Used together with PULLEY WRENCH (18355AA000).
			Used for removing and installing

2010 Subaru Outback R

2010 ENGINE Mechanical (H6DO) - Legacy and Outback

 ST18332AA020	18332AA020	OIL FILTER WRENCH	oil filter.
 ST42099AE000	42099AE000	QUICK CONNECTOR RELEASE	Used for disconnecting quick connector of the engine compartment.
 ST18360AA020	18360AA020 (Newly adopted tool)	HANGER	Used for hanging the engine.

GENERAL TOOL

GENERAL TOOL DESCRIPTION CHART

TOOL NAME	REMARKS
Compression gauge	Used for measuring compression.
Timing light	Used for measuring ignition timing.
Vacuum gauge	Used for measuring intake manifold vacuum.
Oil pressure gauge	Used for measuring engine oil pressure.
Fuel pressure gauge	Used for measuring fuel pressure.
TORX® socket (E12)	Used for removing and installing connecting rod cap.

PROCEDURE

It is possible to conduct the following service procedures with engine on vehicle, however, the procedures described in this article are based on the condition that the engine is removed from vehicle.

- V-belt
- Timing chain

COMPRESSION

INSPECTION

CAUTION: After warming-up, engine becomes very hot. Be careful not to burn yourself during measurement.

1. Remove the collector cover.

NOTE: Follow these procedures for removal of the collector cover.

1. Lift up the rear side holding two positions (A).
2. Lift up the front side holding two positions (B) while moving it in the forward direction of the vehicle.

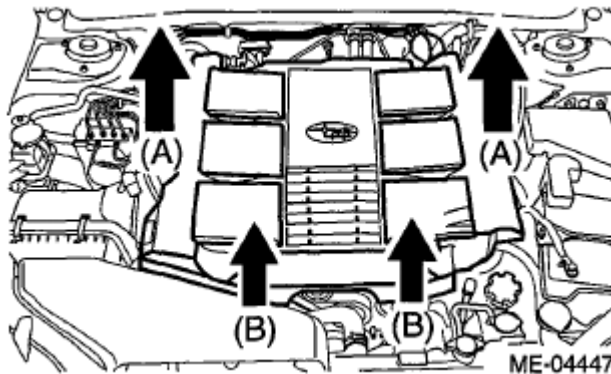
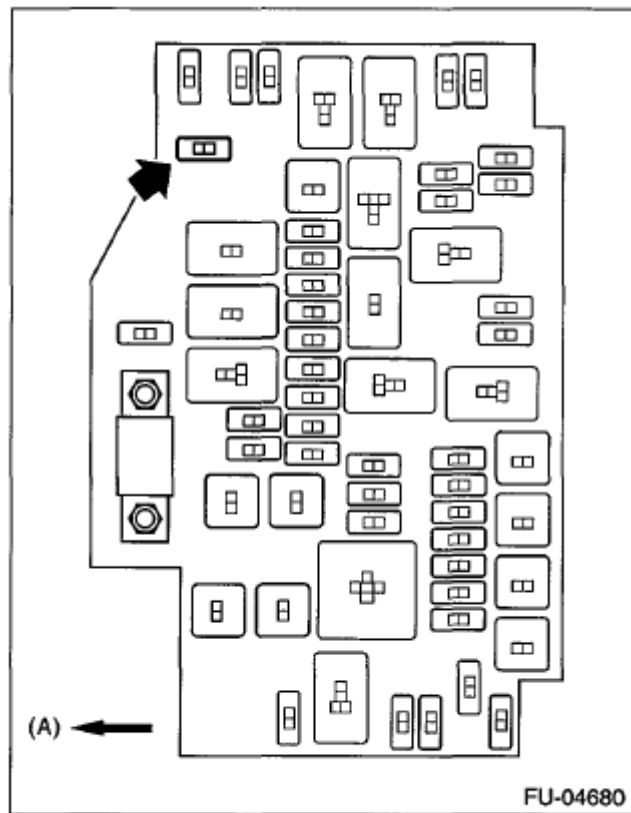


Fig. 10: Locating Front And Rear Side Holding Position
Courtesy of SUBARU OF AMERICA, INC.

2. After warming-up the engine, turn the ignition switch to OFF.
3. Make sure that the battery is fully charged.
4. Remove the fuse of fuel pump from main fuse box.



(A) Front side

Fig. 11: Locating Fuse Of Fuel Pump From Main Fuse Box
 Courtesy of SUBARU OF AMERICA, INC.

5. Start the engine and run it until it stalls.
6. After the engine stalls, crank it for five more seconds.
7. Turn the ignition switch to OFF.
8. Remove all spark plugs. Ref. to **REMOVAL** , Spark Plug.
9. Fully open the throttle valve.
10. Check the starter motor for satisfactory performance and operation.
11. Secure the compression gauge tightly against the spark plug hole.

NOTE: When using a screw-in type compression gauge, the screw should be less than 18 mm (0.71 in) long.

12. Crank the engine by the starter motor, and read the maximum value on the gauge when the needle of gauge is steady.

NOTE: • Perform at least two measurements per cylinder, and make sure that the values are correct.

- If the compression pressure is out of standard, check or adjust the pistons, valves and cylinders.

Compression (350 RPM and fully open throttle): Standard

1,275 - 7,477 kPa (13.0 - 15.0 kgf/cm² , 185 - 213 psi)

Service limit

1,128 kPa (11.5 kgf/cm² , 164 psi)

Difference between cylinders

49 kPa (0.5 kgf/cm² , 7 psi) or less

13. After inspection, install the related parts in the reverse order of removal.

IDLE SPEED

INSPECTION

1. Before checking the idle speed, check the following item:
 1. Check the air cleaner element is free from clogging, ignition timing is correct, spark plugs are in good condition, and hoses are connected properly.
 2. Check the malfunction indicator light does not illuminate.
2. Warm up the engine.
3. Read the engine idle speed using Subaru Select Monitor. Ref. to **READ CURRENT DATA FOR ENGINE (NORMAL MODE)** , OPERATION, Subaru Select Monitor.

NOTE:

- Idle speed cannot be adjusted manually, because the idle speed is automatically adjusted.
- If idle speed is out of standard, refer to the General Diagnosis Table under "Engine Control System". Ref. to **BASIC DIAGNOSTIC PROCEDURE** .

1. Check the idle speed when no-loaded. (Headlight, heater fan, rear defroster, radiator fan, A/C and etc. are OFF)

Idle speed (No load and gears in "P" or "N" range):

Standard 700±100 RPM

2. Check the idle speed when loaded. (Turn the A/C switch to "ON" and operate the compressor for at least one minute before measurement.)

Idle speed (A/C ON and gear in "P" or "N" range):

Standard

700 - 910±100 RPM

IGNITION TIMING

INSPECTION

CAUTION: After warming-up, engine becomes very hot. Be careful not to burn yourself at measurement.

1. METHOD WITH SUBARU SELECT MONITOR

1. Before checking the ignition timing, check the following item:
 1. Check the air cleaner element is free from clogging, spark plugs are in good condition, and hoses are connected properly.
 2. Check the malfunction indicator light does not illuminate.
2. Warm up the engine.
3. Read the ignition timing using Subaru Select Monitor. Ref. to **READ CURRENT DATA FOR ENGINE (NORMAL MODE)**, OPERATION, Subaru Select Monitor.

NOTE: If ignition timing is out of standard, check the ignition control system. Refer to "Engine Control System". Ref. to **BASIC DIAGNOSTIC PROCEDURE**.

Ignition timing [BTDC/RPM]:

Standard 15°±8°/700

2. METHOD WITH TIMING LIGHT

1. Before checking the ignition timing, check the following item:
 1. Check the air cleaner element is free from clogging, spark plugs are in good condition, and hoses are connected properly.
 2. Check the malfunction indicator light does not illuminate.
2. Warm up the engine.
3. Stop the engine, and turn the ignition switch to OFF.
4. Remove the collector cover.

NOTE: Follow these procedures for removal of the collector cover.

1. Lift up the rear side holding two positions (A).
2. Lift up the front side holding two positions (B) while moving it in the forward direction of

the vehicle.

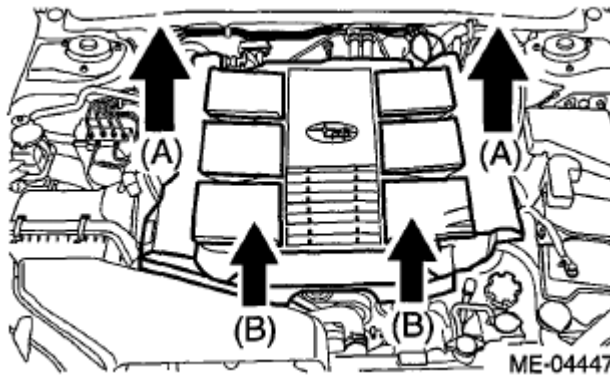


Fig. 12: Locating Front And Rear Side Holding Position
Courtesy of SUBARU OF AMERICA, INC.

5. Disconnect the ground cable from battery.
6. Remove the air intake duct. Ref. to **REMOVAL** , Air Intake Duct.
7. Disconnect the connector from mass air flow and intake air temperature sensor.
8. Remove the air cleaner case and element.
9. Connect the timing light to the power wire of #1 ignition coil.
10. Install the connectors of air cleaner case, element, and the mass air flow and intake air temperature sensor.
11. Connect the ground cable to battery.
12. Start the engine, turn the timing light to the crank pulley, and check the ignition timing through the chain cover gauge.

NOTE: If ignition timing is out of standard, check the ignition control system. Refer to "Engine Control System". Ref. to **BASIC DIAGNOSTIC PROCEDURE** .

Ignition timing [BTDC/RPM]:

Standard $15^{\circ} \pm 8^{\circ} / 700$

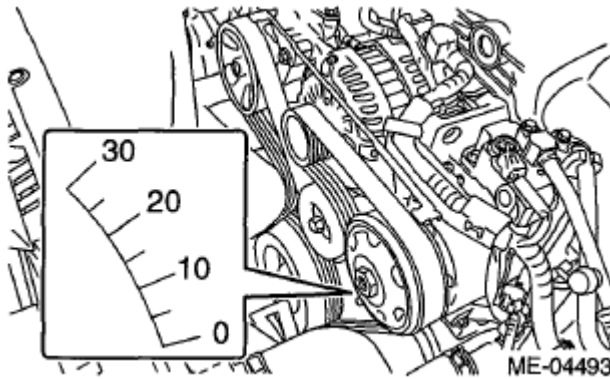


Fig. 13: Identifying Ignition Timing
 Courtesy of SUBARU OF AMERICA, INC.

13. After inspection, install the related parts in the reverse order of removal.

INTAKE MANIFOLD VACUUM

INSPECTION

1. Warm up the engine.
2. Remove the collector cover.

NOTE: Follow these procedures for removal of the collector cover.

1. Lift up the rear side holding two positions (A).
2. Lift up the front side holding two positions (B) while moving it in the forward direction of the vehicle.

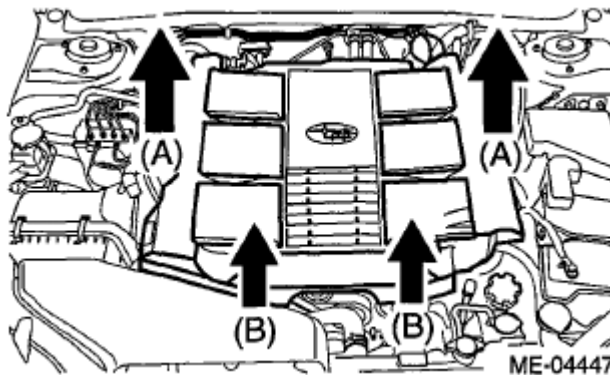


Fig. 14: Locating Front And Rear Side Holding Position
 Courtesy of SUBARU OF AMERICA, INC.

3. Remove the air intake boot. Ref. to **REMOVAL** , Air Intake Boot.
4. Disconnect the brake booster vacuum hose from the intake manifold, and attach the vacuum gauge.

5. Install the air intake boot. Ref. to **INSTALLATION** , Air Intake Boot.
6. Keep the engine at idle speed and read the vacuum gauge indication.

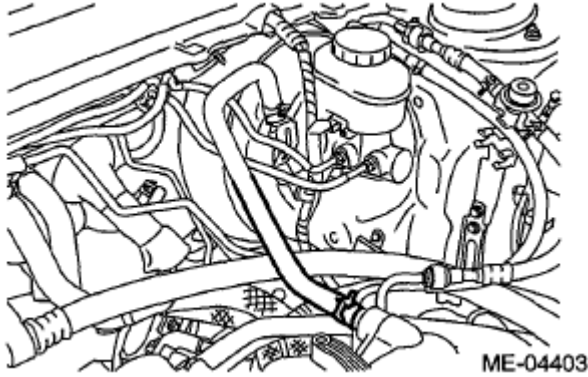


Fig. 15: Identifying Brake Booster Vacuum Hose Of Intake Manifold
 Courtesy of SUBARU OF AMERICA, INC.

NOTE: Condition of engine inside can be diagnosed by observing the behavior of the vacuum gauge needle as described in table below.

Intake manifold vacuum (at idling, A/C OFF):

Standard Less than -60.0 kPa (-450 mmHg, -17.72 inHg)

INTAKE MANIFOLD VACUUM SPECIFICATION CHART

Diagnosis of engine condition by measurement of intake manifold vacuum	
Vacuum gauge indication	Possible engine condition
1. Needle is steady but lower than standard value. This tendency becomes more evident as engine temperature rises.	Leakage around intake manifold gasket, disconnection or damage of vacuum hose
2. Needle intermittently drops to position lower than standard value.	Leakage around cylinder
3. Needle drops suddenly and intermittently from standard value.	Sticky valve
4. When engine speed is gradually increased, needle begins to vibrate rapidly at certain speed, and then vibration increases as engine speed increases.	Weak or broken valve springs
5. Needle vibrates above and below standard value in narrow range.	Defective ignition system

ENGINE OIL PRESSURE

INSPECTION

1. Disconnect the ground cable from battery.

2. Remove the oil pressure switch from the oil pan upper. Ref. to **REMOVAL** , Oil Pressure Switch.
3. Attach the oil pressure gauge to the oil pan upper.
4. Connect the ground cable to battery.
5. Start the engine, and measure the oil pressure.

NOTE:

- If the oil pressure is out of specification, check oil pump, oil filter and lubrication line. Ref. to **ENGINE LUBRICATION SYSTEM TROUBLE IN GENERAL** .
- If the oil pressure warning light is ON and oil pressure is within specification, check the oil pressure switch. Ref. to **OIL PRESSURE SYSTEM** . Ref. to **OIL PRESSURE SWITCH** .

Engine oil pressure (at oil temperature of 80°C (176°F)):

Standard

100 kPa (1.0 kgf/cm² , 15 psi) or more (at 700 RPM)

500 kPa (5.1 kgf/cm² , 73 psi) or more (at 5,000 RPM)

6. After inspection, install the related parts in the reverse order of removal.

FUEL PRESSURE**INSPECTION****CAUTION:**

- Before removing the fuel pressure gauge, release the fuel pressure.
- Be careful not to spill fuel.
- Catch the fuel from hoses using a container or cloth.

1. Remove the collector cover.

NOTE:

Follow these procedures for removal of the collector cover.

1. Lift up the rear side holding two positions (A).
2. Lift up the front side holding two positions (B) while moving it in the forward direction of the vehicle.

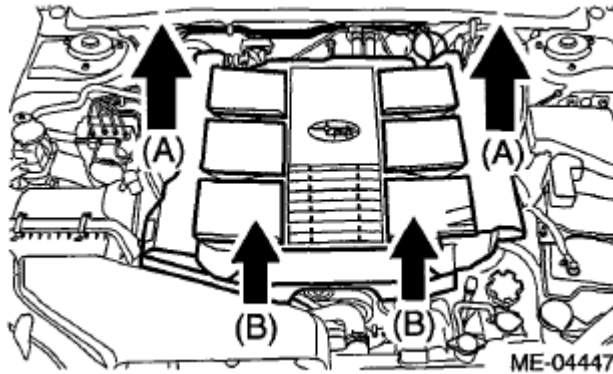


Fig. 16: Locating Front And Rear Side Holding Position
Courtesy of SUBARU OF AMERICA, INC.

2. Release the fuel pressure. Ref. to **RELEASING OF FUEL PRESSURE** , PROCEDURE, Fuel.
3. Open the fuel filler lid and remove the fuel filler cap.
4. Disconnect the fuel delivery hose from the fuel damper, and connect the fuel pressure gauge.

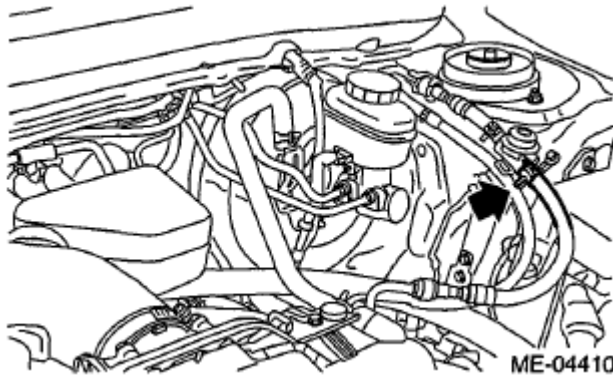


Fig. 17: Locating Fuel Delivery Hose Of Fuel Damper
Courtesy of SUBARU OF AMERICA, INC.

5. Start the engine.
6. Measure the fuel pressure after warming up the engine.

NOTE:

- The fuel pressure gauge registers 10 to 20 kPa (0.1 to 0.2 kgf/cm² , 1 to 3 psi) higher than standard values during high-altitude operations.
- Check or replace the fuel pump and fuel delivery line if the fuel pressure is out of the standard.

Fuel pressure:

Standard

338 - 348 kPa (3.4 - 3.5 kgf/cm² , 49 - 50.5 psi)

7. After inspection, install the related parts in the reverse order of removal.

VALVE CLEARANCE

INSPECTION

CAUTION: If engine oil is spilt onto the exhaust pipe, wipe it off with cloth to avoid emission of smoke or causing a fire.

NOTE: Inspection of valve clearance should be performed while engine is cold.

1. Remove the collector cover.

NOTE: Follow these procedures for removal of the collector cover.

1. Lift up the rear side holding two positions (A).
2. Lift up the front side holding two positions (B) while moving it in the forward direction of the vehicle.

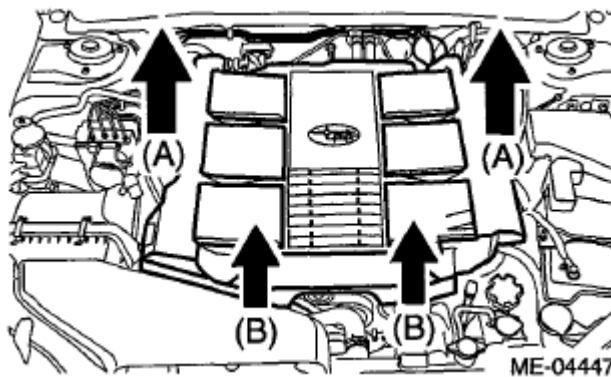


Fig. 18: Locating Front And Rear Side Holding Position
Courtesy of SUBARU OF AMERICA, INC.

2. Disconnect the ground cable from battery.
3. Lift up the vehicle.
4. Remove the under cover. Ref. to **REMOVAL** , Front Under Cover.
5. Lower the vehicle.
6. When inspecting #1, #3 and #5 cylinders
 1. Remove the air intake duct, air cleaner case and air intake boot assembly. Ref. to **REMOVAL** , Air Intake Duct. Ref. to **REMOVAL** , Air Cleaner Case. Ref. to **REMOVAL** , Air Intake Boot.
 2. Remove the fuel pipe protector (RH).

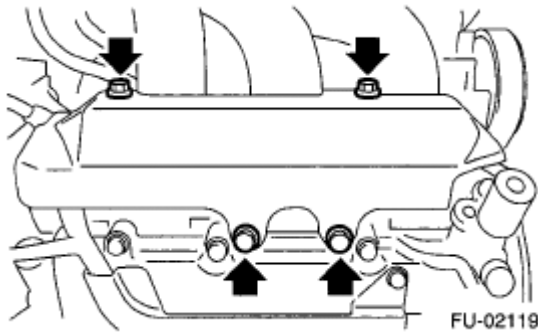


Fig. 19: Locating Fuel Pipe Protector (RH) Bolts
Courtesy of SUBARU OF AMERICA, INC.

3. Disconnect the connector of oil pressure switch.
4. Remove the ignition coil. Ref. to **REMOVAL**, Ignition Coil.
5. Remove the rocker cover (RH). Ref. to **REMOVAL**, Camshaft.
7. When inspecting #2, #4 and #6 cylinders
 1. Disconnect the battery cable, and then remove the battery and battery carrier. Ref. to **REMOVAL**, Battery.
 2. Remove two fixing clips on the fuel pipe protector (LH).

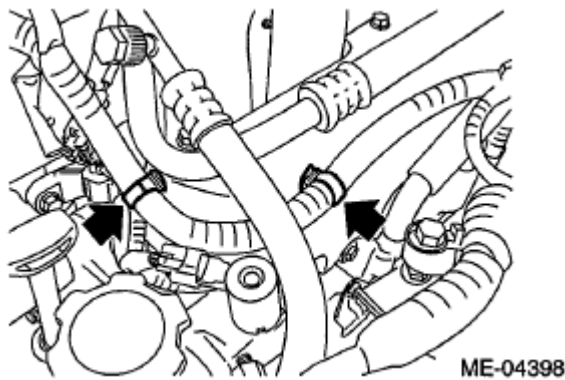
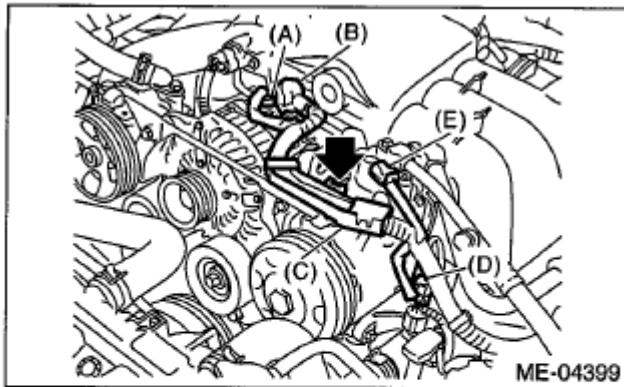


Fig. 20: Locating Fuel Pipe Protector (LH) Clips
Courtesy of SUBARU OF AMERICA, INC.

3. Generator connector
4. Generator terminal B
5. Remove the harness cover from collector cover bracket.
6. A/C compressor solenoid connector
7. Flow sensor connector



- (A) Generator connector
- (B) Terminal B
- (C) Harness cover
- (D) A/C compressor solenoid connector
- (E) Flow sensor connector

Fig. 21: Identifying Generator Connector, Terminal B, Harness Cover, Flow Sensor Connector

Courtesy of SUBARU OF AMERICA, INC.

8. Slide the harness and connector to the battery side.
9. Disconnect the PCV hose and blow-by hose from the rocker cover (LH).

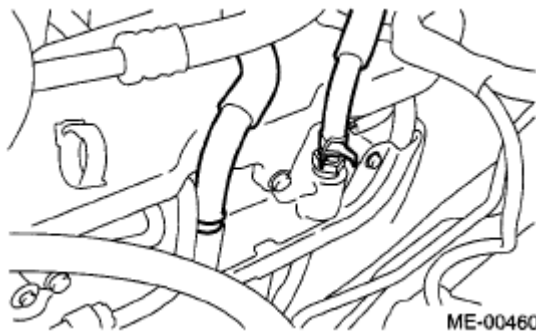


Fig. 22: Identifying PCV Hose And Blow-By Hose

Courtesy of SUBARU OF AMERICA, INC.

10. Remove the fuel pipe protector (LH).

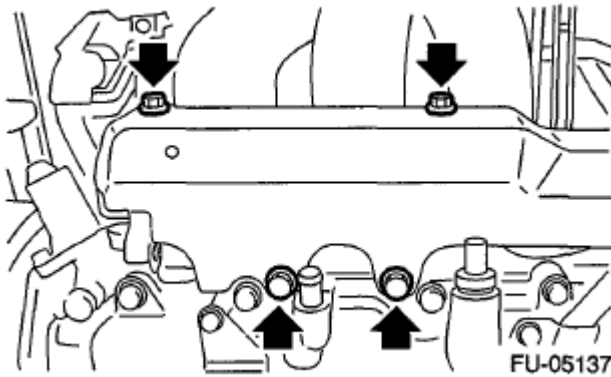
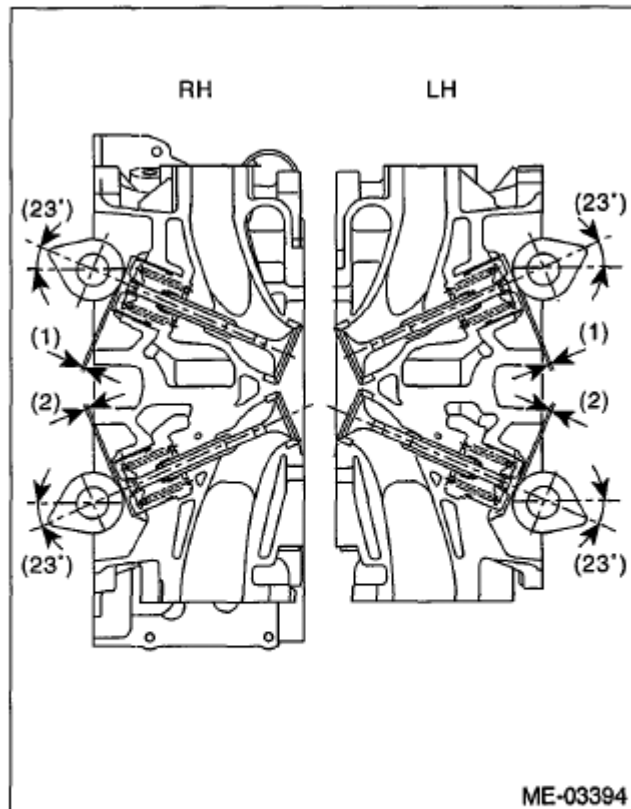


Fig. 23: Locating Fuel Pipe Protector (LH) Bolts
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the ignition coil. Ref. to **REMOVAL**, Ignition Coil.
12. Remove the rocker cover (LH). Ref. to **REMOVAL**, Camshaft.
8. Turn the crankshaft clockwise until the camshaft is set to position shown in the figure.



- (1) Valve clearance (Intake side)
- (2) Valve clearance (Exhaust side)

Fig. 24: Position Of Turning Crankshaft
Courtesy of SUBARU OF AMERICA, INC.

9. Measure the clearance of intake valve and exhaust valve using thickness gauge (A).

NOTE:

- Measure it within the range of $\pm 30^\circ$ from specified position shown in the figure.
- Insert a thickness gauge in a direction as horizontal as possible with respect to the valve lifter.

Valve clearance (inspection value):

Intake

$0.20^{+0.04}_{-0.06} \text{ mm } (0.0079^{+0.0016}_{-0.0024} \text{ in})$

Exhaust

$0.35 \pm 0.05 \text{ mm } (0.0138 \pm 0.0020 \text{ in})$

- If the measured value is not within specification, take notes of the value in order to adjust the valve clearance later on.

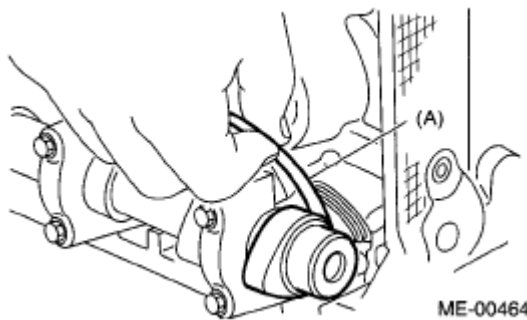


Fig. 25: Measuring Clearance Of Intake Valve And Exhaust Valve Using Thickness Gauge
Courtesy of SUBARU OF AMERICA, INC.

10. If necessary, adjust the valve clearance. Ref. to ADJUSTMENT, Valve Clearance.
11. Further turn the crank pulley clockwise and then measure the valve clearances again.
12. After inspection, install the related parts in the reverse order of removal. Ref. to INSTALLATION, Camshaft.

ADJUSTMENT**INTAKE SIDE**

CAUTION: If engine oil is spilt onto the exhaust pipe, wipe it off with cloth to avoid emission of smoke or causing a fire.

NOTE: Adjustment of valve clearance should be performed while engine is cold.

1. Measure all the valve clearances. Ref. to INSPECTION, Valve Clearance.

NOTE: Record each valve clearance after measurement.

2. Remove the timing chain assembly. Ref. to REMOVAL, Timing Chain Assembly.
3. Remove the cam sprocket. Ref. to REMOVAL, Cam Sprocket.
4. Remove the camshaft. Ref. to REMOVAL, Camshaft.
5. Remove the valve lifter.
6. Measure the thickness of valve lifter using micrometer.

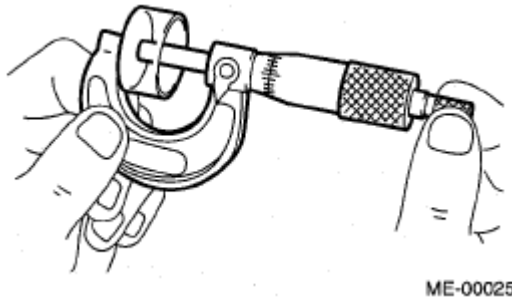


Fig. 26: Measuring Thickness Of Valve Lifter With Micrometer
Courtesy of SUBARU OF AMERICA, INC.

7. Select a valve lifter of suitable thickness using the measured valve clearance and valve lifter thickness, and install it.

NOTE: Use a new valve lifter.

VALVE LIFTER THICKNESS CHART

Unit: mm (in)
$S = (V + T) - 0.20 (0.0079)$
S: Valve lifter thickness required
V: Measured valve clearance
T: Valve lifter thickness to be used

8. Install the camshaft. Ref. to INSTALLATION, Camshaft.
9. Install the cam sprocket. Ref. to INSTALLATION, Cam Sprocket.
10. Install the timing chain assembly. Ref. to INSTALLATION, Timing Chain Assembly.
11. Measure all valve clearance again at this time. If the valve clearance is not correct, repeat the procedure over again from the first step.

Valve clearance (adjustment value):

$$0.20^{+0.04}_{-0.03} \text{ mm } (0.0079^{+0.0016}_{-0.0024} \text{ in})$$

12. After measuring, install the related parts in the reverse order of removal.

NOTE: Use a new rocker cover gasket.

EXHAUST SIDE

CAUTION: If engine oil is spilt onto the exhaust pipe, wipe it off with cloth to avoid emission of smoke or causing a fire.

NOTE: Adjustment of valve clearance should be performed while engine is cold.

1. Measure all the valve clearances. Ref. to INSPECTION, Valve Clearance.

NOTE: Record each valve clearance after measurement.

2. Remove the camshaft. Ref. to REMOVAL, Camshaft.
3. Remove the valve lifter.
4. Measure the thickness of valve lifter using micrometer.

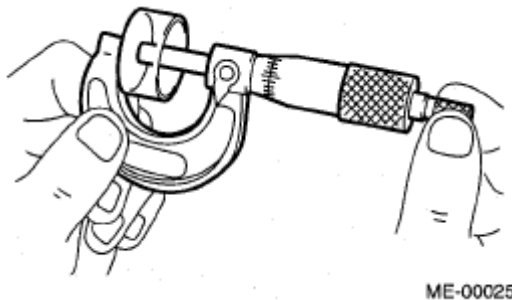


Fig. 27: Measuring Thickness Of Valve Lifter With Micrometer
Courtesy of SUBARU OF AMERICA, INC.

5. Select a valve lifter of suitable thickness using the measured valve clearance and valve lifter thickness, and install it.

NOTE: Use a new valve lifter.

VALVE LIFTER THICKNESS CHART

Unit: mm (in)
$S = (V + T) - 0.35 \text{ (0.0138)}$
S: Valve lifter thickness required
V: Measured valve clearance

T: Valve lifter thickness to be used

6. Install the camshaft. Ref. to **INSTALLATION**, Camshaft.
7. Install the cam sprocket. Ref. to **INSTALLATION**, Cam Sprocket.
8. Install the timing chain assembly. Ref. to **INSTALLATION**, Timing Chain Assembly.
9. Measure all valve clearance again at this time. If the valve clearance is not correct, repeat the procedure over again from the first step.

Valve clearance (adjustment value):

$0.35 \pm 0.05 \text{ mm}$ ($0.0138 \pm 0.0020 \text{ in}$)

10. After measuring, install the related parts in the reverse order of removal.

NOTE: Use a new rocker cover gasket.

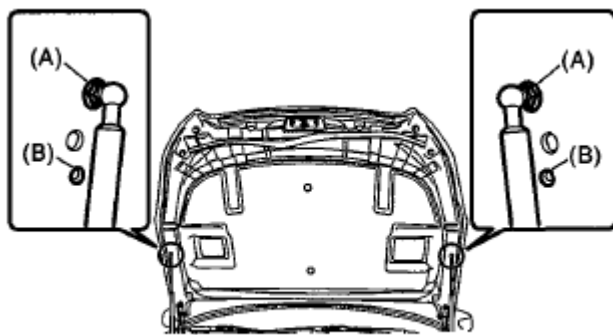
ENGINE ASSEMBLY

REMOVAL

1. Change the front hood damper bolt mounting position from (A) to (B), and completely open the front hood.

Tightening torque:

20 N.m (2.0 kgf-m , 14.8 ft-lb)



ME-04396

Fig. 28: Identifying Front Hood Damper Bolt Mounting Position
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the collector cover.

NOTE: Follow these procedures for removal of the collector cover.

1. Lift up the rear side holding two positions (A).
2. Lift up the front side holding two positions (B) while moving it in the forward direction of the vehicle.

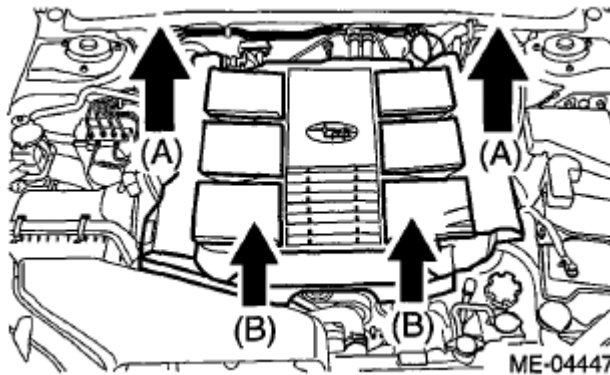


Fig. 29: Locating Front And Rear Side Holding Position
 Courtesy of SUBARU OF AMERICA, INC.

3. Collect the refrigerant from A/C system. Ref. to **PROCEDURE** , Refrigerant Recovery Procedure.
4. Release the fuel pressure. Ref. to **PROCEDURE** , Fuel.
5. Disconnect the ground cable from battery.
6. Open the fuel filler lid and remove the fuel filler cap.
7. Remove the air intake duct, air cleaner case and air intake boot assembly. Ref. to **REMOVAL** , Air Intake Duct. Ref. to **REMOVAL** , Air Cleaner Case. Ref. to **REMOVAL** , Air Intake Boot.
8. Remove the V-belts. Ref. to **REMOVAL** , V-belt.
9. Disconnect the following connector.
 1. Remove two fixing clips on the fuel pipe protector (LH).

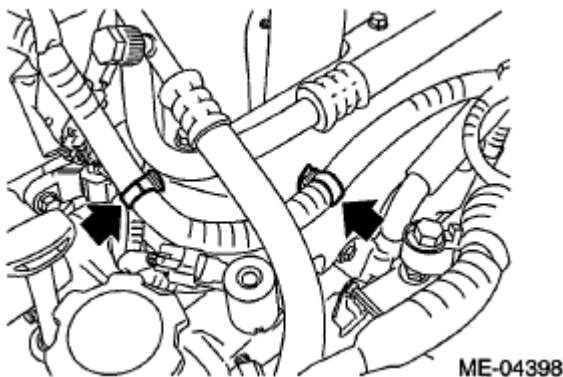
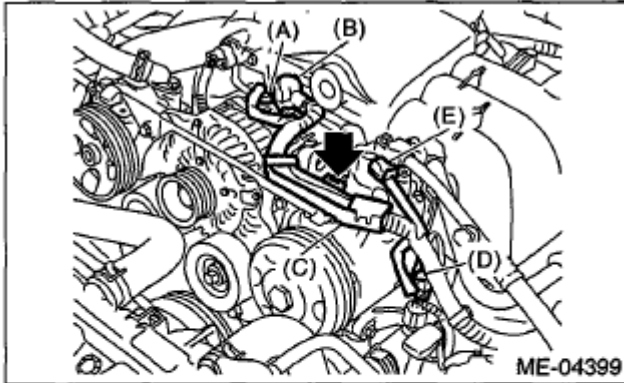


Fig. 30: Locating Fuel Pipe Protector (LH) Clips
 Courtesy of SUBARU OF AMERICA, INC.

2. Generator connector
3. Generator terminal B

4. Remove the harness cover from collector cover bracket.
5. A/C compressor solenoid connector
6. Flow sensor connector



- (A) Generator connector
- (B) Terminal B
- (C) Harness cover
- (D) A/C compressor solenoid connector
- (E) Flow sensor connector

Fig. 31: Identifying Generator Connector, Terminal B, Harness Cover, Flow Sensor Connector
 Courtesy of SUBARU OF AMERICA, INC.

7. Slide the harness and connector to the battery side.
10. Remove the power steering pump together with the bracket.

NOTE: Do not disconnect the hose and pipe from the power steering pump.

1. Disconnect the manifold absolute pressure sensor connector (A) and power steering pump connector (B).

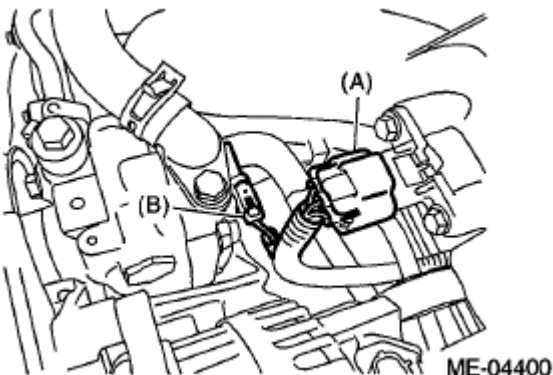


Fig. 32: Identifying Manifold Absolute Pressure Sensor Connector And Power Steering Pump Connector
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the securing bolts of collector cover bracket and power steering pump bracket.

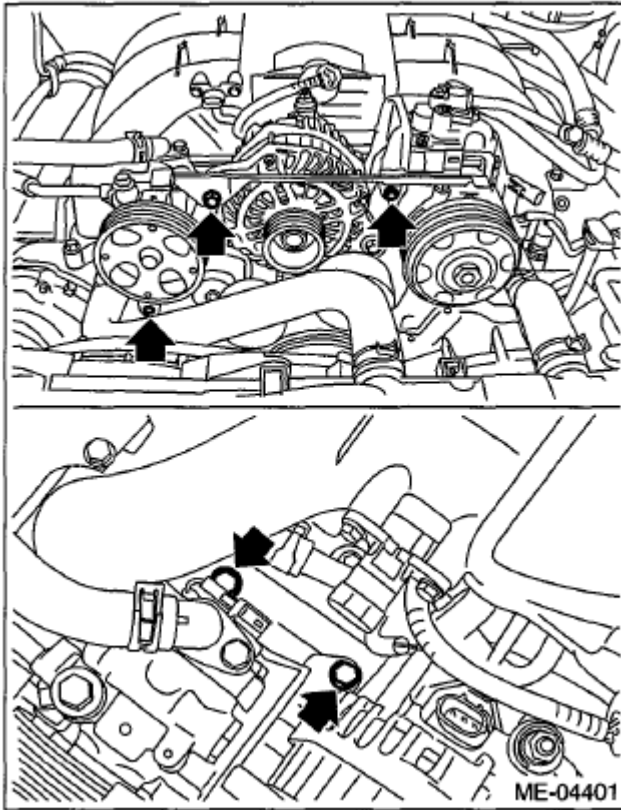


Fig. 33: Locating Collector Cover Bracket And Power Steering Pump Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

3. Use a cloth to protect the power steering pump and place it on the RH front strut using a wire.



Fig. 34: Identifying Power Steering Pump

Courtesy of SUBARU OF AMERICA, INC.

11. Remove the brake booster vacuum hose.

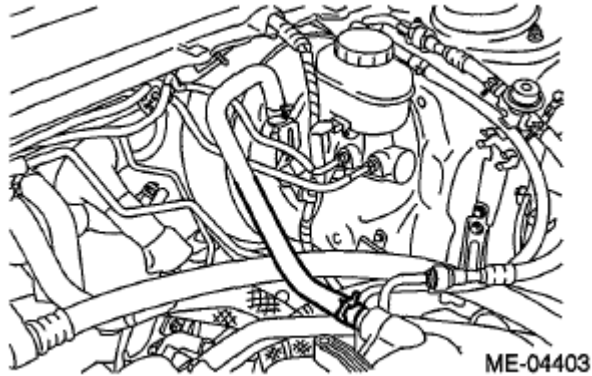


Fig. 35: Identifying Brake Booster Vacuum Hose
Courtesy of SUBARU OF AMERICA, INC.

12. Remove the engine ground.

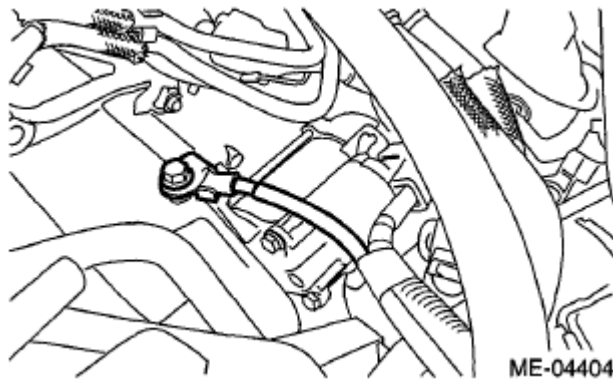


Fig. 36: Identifying Engine Ground
Courtesy of SUBARU OF AMERICA, INC.

13. Remove the starter harness and engine ground from bracket.

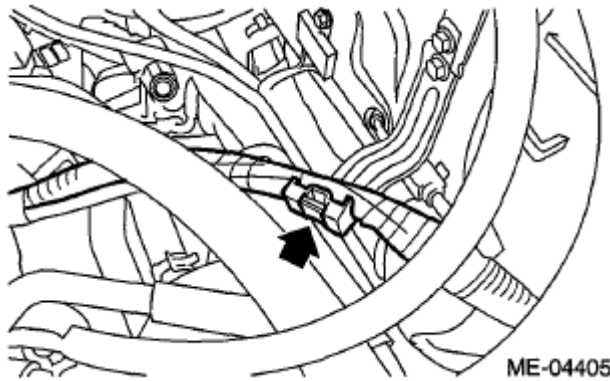


Fig. 37: Locating Starter Harness And Engine Ground
Courtesy of SUBARU OF AMERICA, INC.

14. Remove the starter. Ref. to **REMOVAL** , Starter.
15. Remove the grille bracket.

NOTE: Remove ten clips when removing the grille bracket.

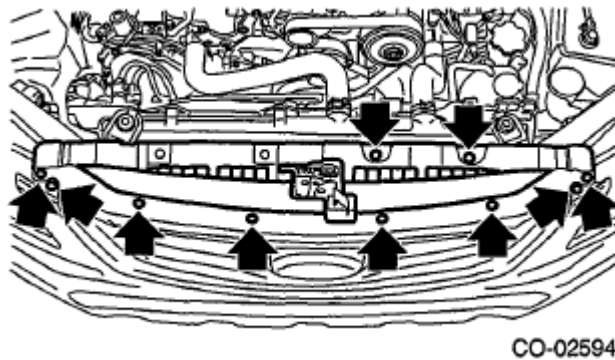


Fig. 38: Locating Grille Bracket Clips
Courtesy of SUBARU OF AMERICA, INC.

16. Lift up the vehicle.
17. Remove the under cover. Ref. to **REMOVAL** , Front Under Cover.
18. Drain engine coolant completely. Ref. to **DRAINING OF ENGINE COOLANT** , REPLACEMENT, Engine Coolant.
19. Remove the front exhaust pipe. Ref. to **REMOVAL** , Front Exhaust Pipe.
20. Remove the ground cable from the underside of chain cover.

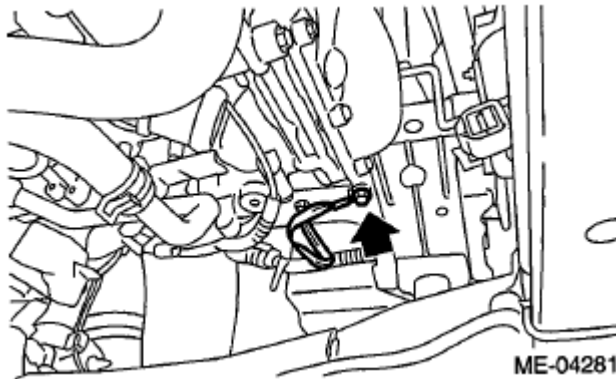


Fig. 39: Locating Ground Cable Bolt From Underside Of Chain Cover
Courtesy of SUBARU OF AMERICA, INC.

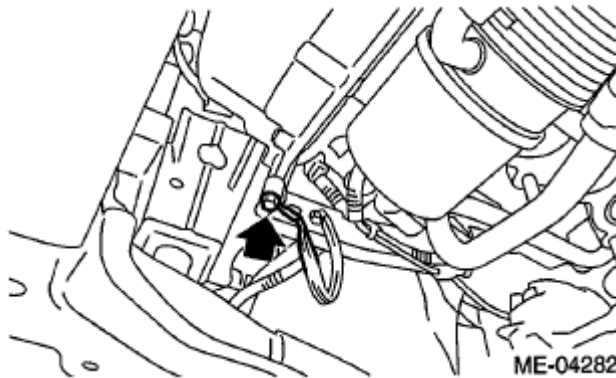


Fig. 40: Locating Ground Cable Bolt From Underside Of Chain Cover
Courtesy of SUBARU OF AMERICA, INC.

21. Remove the connecting bolts and nuts (lower side) between the engine and transmission.

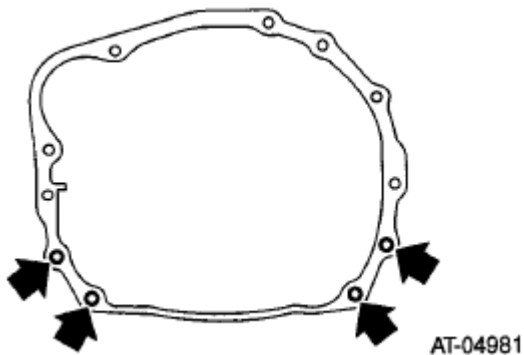


Fig. 41: Locating Bolts And Nuts (Lower Side) Of Engine And Transmission
Courtesy of SUBARU OF AMERICA, INC.

22. Lower the vehicle.
23. Remove the radiator main fan & fan motor and radiator sub fan & fan motor. Ref. to **REMOVAL**,

Radiator Main Fan and Fan Motor. Ref. to **REMOVAL** , Radiator Sub Fan and Fan Motor.

24. Remove the radiator. Ref. to **REMOVAL** , Radiator.
25. Remove the heater inlet hose and heater outlet hose.

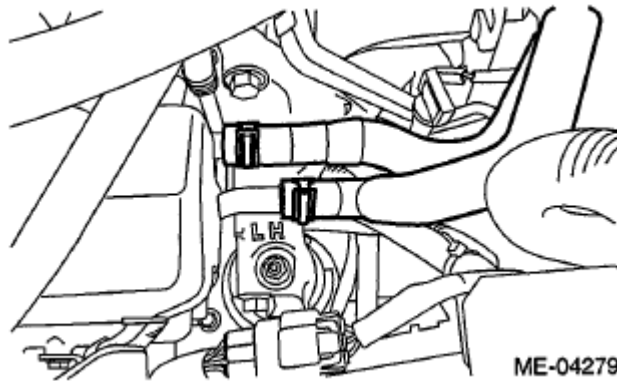


Fig. 42: Identifying Heater Inlet Hose And Heater Outlet Hose
Courtesy of SUBARU OF AMERICA, INC.

26. Disconnect the engine harness connector.

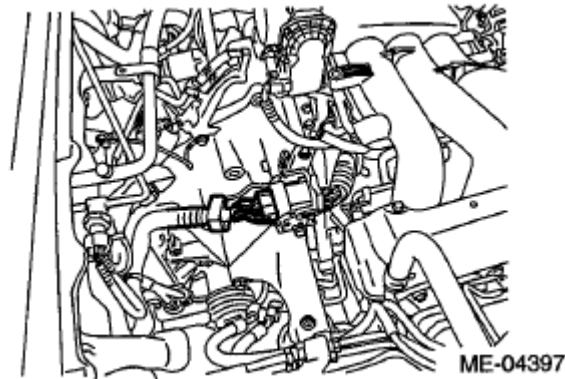


Fig. 43: Identifying Engine Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

27. Disconnect the connector from the throttle body.

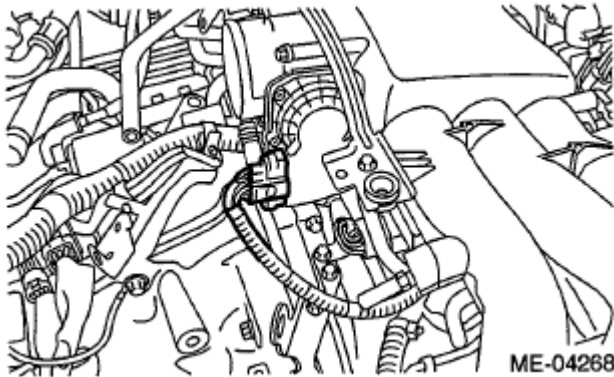


Fig. 44: Identifying Throttle Body Connector
Courtesy of SUBARU OF AMERICA, INC.

28. Remove the engine harness connector from the engine hanger bracket.

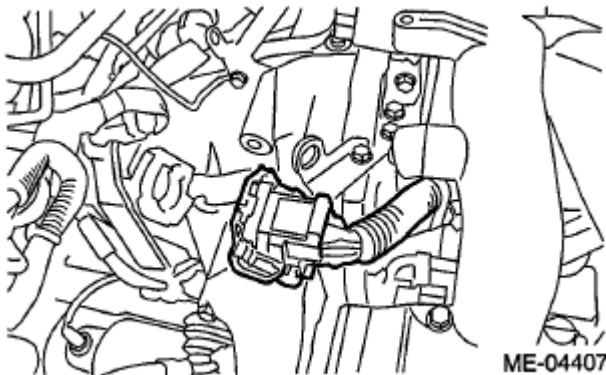


Fig. 45: Identifying Engine Harness Connector Of Engine Hanger Bracket
Courtesy of SUBARU OF AMERICA, INC.

29. Remove the engine hanger bracket.

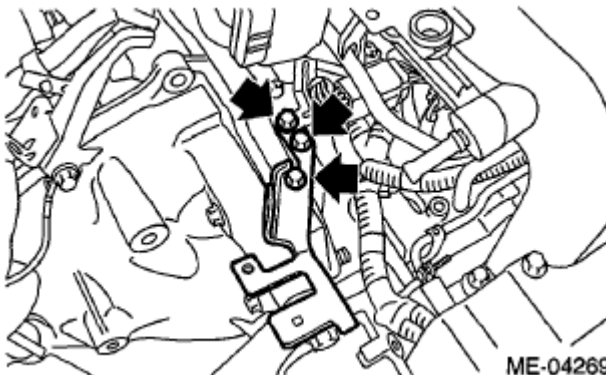


Fig. 46: Locating Engine Hanger Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

30. Remove the throttle body from the intake manifold.

NOTE: Do not disconnect the inlet and outlet hoses of engine coolant.

31. Attach the ST.

ST 18360AA020 HANGER

Tightening torque:

19 N.m (1.9 kgf-m, 14.0 ft-lb)

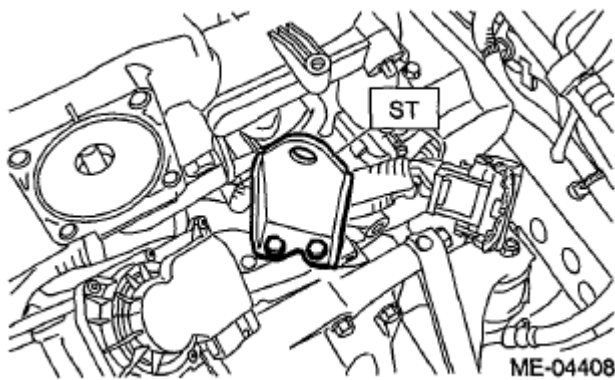


Fig. 47: Removing Throttle Body From Intake Manifold Using ST
Courtesy of SUBARU OF AMERICA, INC.

32. Separate the torque converter clutch from drive plate.
1. Remove the service hole plug.

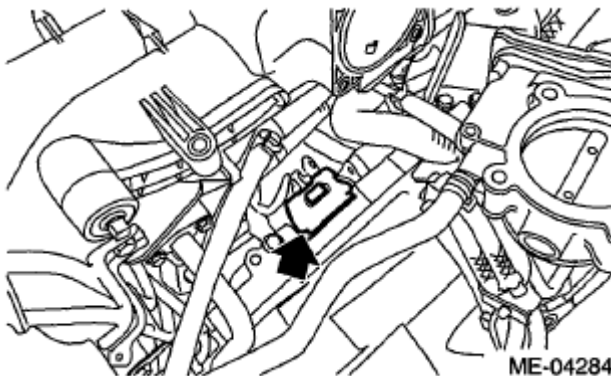


Fig. 48: Locating Service Hole Plug
Courtesy of SUBARU OF AMERICA, INC.

2. Rotate the crank pulley to align the drive plate to the service hole, and remove four bolts.
33. Disconnect the fuel delivery hose and evaporation hose.

CAUTION:

- Be careful not to spill fuel.
- Catch the fuel from hoses using a container or cloth.

1. Attach ST to the fuel delivery pipe and push ST in the direction of arrow mark to disconnect the quick connector of the fuel delivery hose.

ST 42099AE000 QUICK CONNECTOR RELEASE

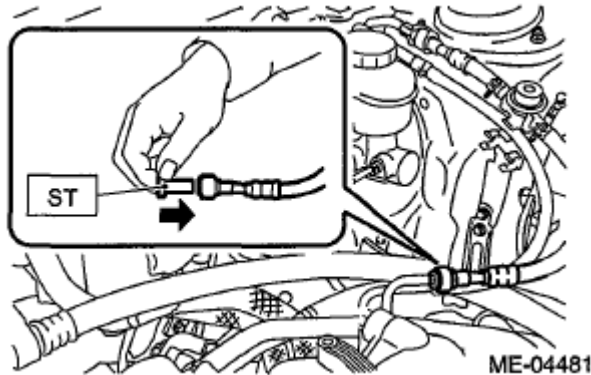


Fig. 49: Attaching ST To Fuel Delivery Pipe
Courtesy of SUBARU OF AMERICA, INC.

2. Remove the clip and disconnect the evaporation hose.
34. Disconnect the A/C pressure hoses from A/C compressor. Ref. to **REMOVAL** , Hose and Pipe.
35. Remove the connecting bolts (upper side) between engine and transmission.

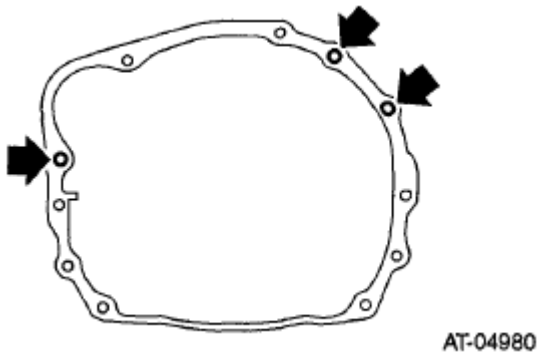


Fig. 50: Locating Bolts (Upper Side) Of Engine And Transmission
Courtesy of SUBARU OF AMERICA, INC.

36. Set the ST to torque converter clutch case.

ST 498277200 STOPPER SET

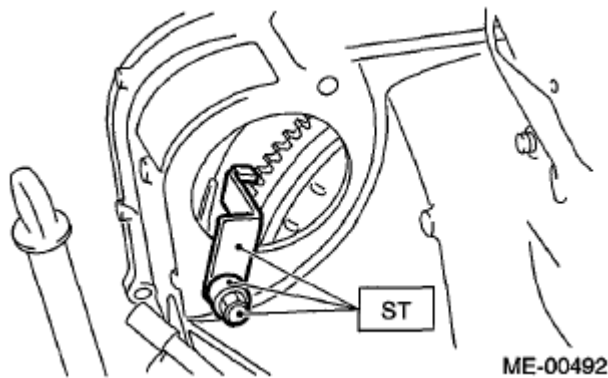


Fig. 51: Setting ST To Torque Converter Clutch Case
 Courtesy of SUBARU OF AMERICA, INC.

37. Support the engine with a lifting device and wire ropes.

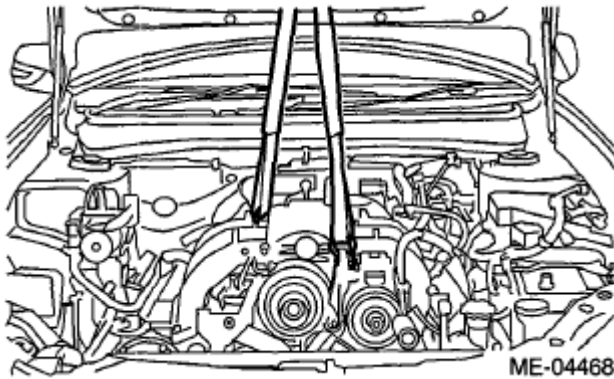


Fig. 52: Supporting Engine With Lifting Device And Wire Ropes
 Courtesy of SUBARU OF AMERICA, INC.

38. Remove the front mount.

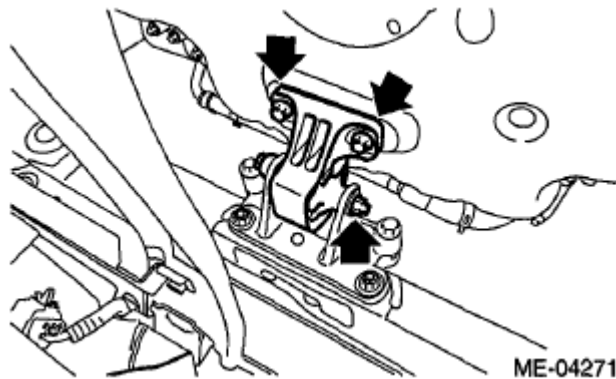


Fig. 53: Locating Front Mount
 Courtesy of SUBARU OF AMERICA, INC.

39. Remove the front mounting bracket from the cradle.

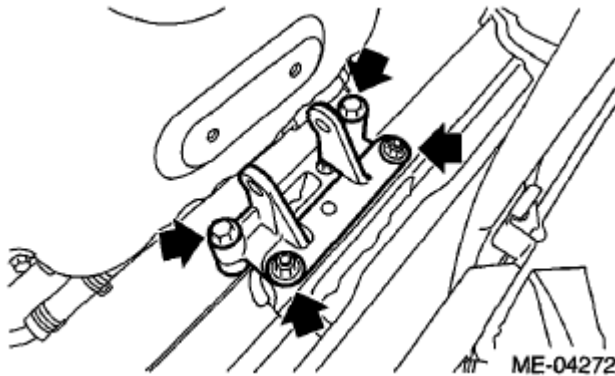


Fig. 54: Locating Front Mounting Bracket Of Cradle
Courtesy of SUBARU OF AMERICA, INC.

40. Remove the engine from the engine compartment.
 1. Operate the lifter to set the engine horizontally.
 2. Move the engine towards the front of the vehicle to disconnect it from the torque converter clutch case.
 3. Operate the lifter to take out the engine from the engine compartment.

NOTE: Be careful not to damage adjacent parts or body panels with crank pulley, oil level gauge, etc.

INSTALLATION

1. Install the engine to the vehicle.
 1. Operate the lifter to place the engine in the engine compartment.
 2. Operate the lifter to set the engine horizontally.
 3. Move the engine towards the rear of the vehicle to connect it to the torque converter clutch case.

NOTE: Be careful not to damage adjacent parts or body panels with crank pulley, oil level gauge, etc.

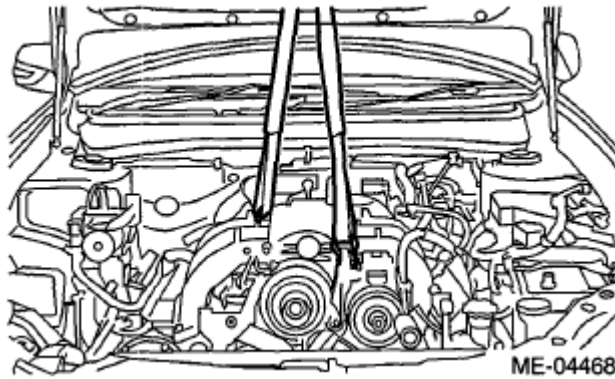


Fig. 55: Supporting Engine With Lifting Device And Wire Ropes
Courtesy of SUBARU OF AMERICA, INC.

2. Install front mounting bracket to the cradle.

Tightening torque:

60 N.m (6.1 kgf-m, 44.3 ft-lb)

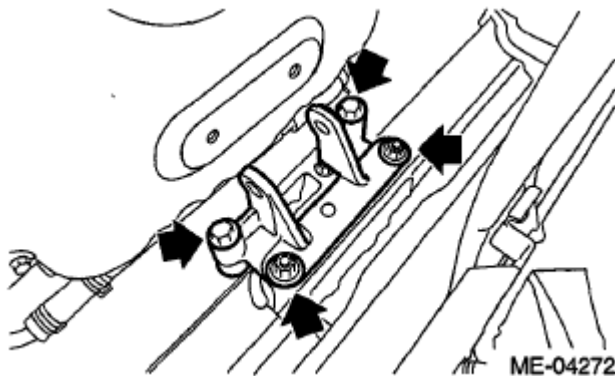


Fig. 56: Locating Front Mounting Bracket Of Cradle
Courtesy of SUBARU OF AMERICA, INC.

3. Install the front mount.

Tightening torque:

T1:25 N.m (2.5 kgf-m, 18.4 ft-lb)

T2:45 N.m (4.6 kgf-m, 33.2 ft-lb)

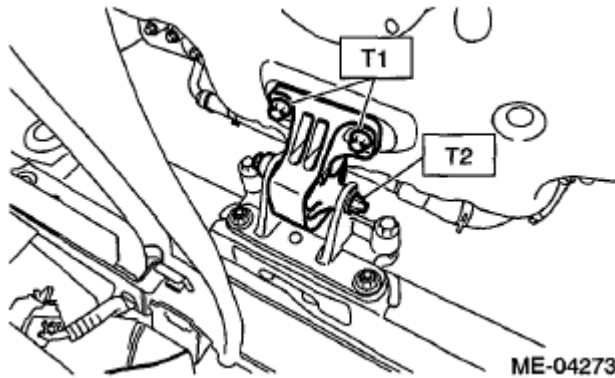


Fig. 57: Locating Front Mount
Courtesy of SUBARU OF AMERICA, INC.

4. Install the connecting bolts (upper side) between engine and transmission.

Tightening torque:

50 N.m (5.1 kgf-m, 36.9 ft-lb)

NOTE: Make sure there are no gaps in the mating surfaces between engine and transmission. If there are gaps, loosen the connecting bolts, and adjust the position while retightening the bolts.

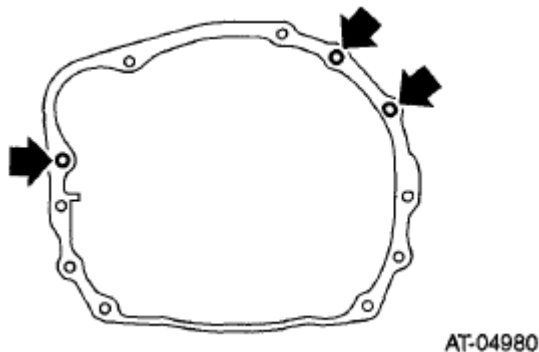


Fig. 58: Locating Bolts (Upper Side) Of Engine And Transmission
Courtesy of SUBARU OF AMERICA, INC.

5. Remove the lifting device and wire ropes.
6. Remove the ST from torque converter clutch case.

NOTE: Be careful not to drop the ST into the torque converter clutch case when removing the ST.

7. Install the radiator. Ref. to **INSTALLATION** , Radiator.
8. Install the radiator main fan & fan motor and radiator sub fan & fan motor. Ref. to **INSTALLATION** ,

Radiator Main Fan and Fan Motor. Ref. to **INSTALLATION** , Radiator Sub Fan and Fan Motor.

9. Lift up the vehicle.
10. Attach the connecting bolts and nuts (lower side) between the engine and transmission.

Tightening torque:

50 N.m (5.1 kgf-m, 36.9 ft-lb)

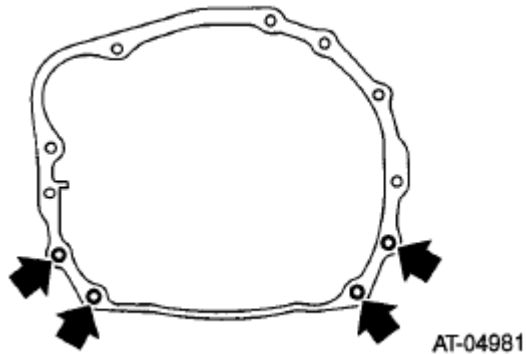


Fig. 59: Locating Bolts And Nuts (Lower Side) Of Engine And Transmission
Courtesy of SUBARU OF AMERICA, INC.

11. Install the ground cable to the underside of chain cover.

Tightening torque:

7.5 N.m (0.8 kgf-m, 5.5 ft-lb)

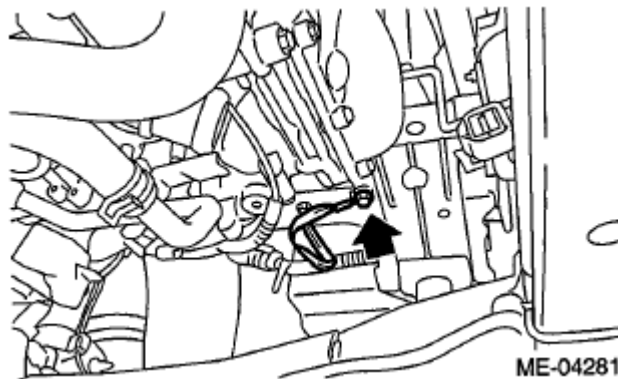


Fig. 60: Locating Ground Cable Bolt From Underside Of Chain Cover
Courtesy of SUBARU OF AMERICA, INC.

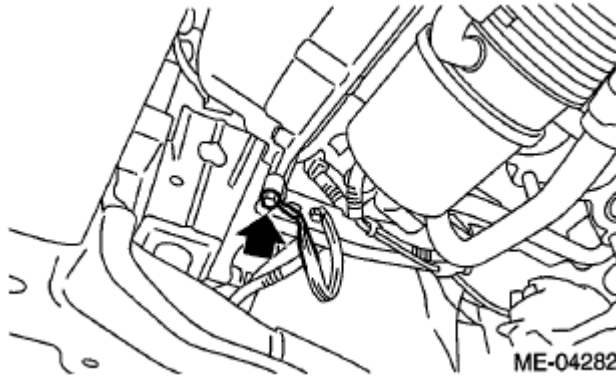


Fig. 61: Locating Ground Cable Bolt From Underside Of Chain Cover
Courtesy of SUBARU OF AMERICA, INC.

12. Install the front exhaust pipe. Ref. to **INSTALLATION** , Front Exhaust Pipe.
13. Install the undercover. Ref. to **INSTALLATION** , Front Under Cover.
14. Lower the vehicle.
15. Install the A/C pressure hoses to A/C compressor. Ref. to **INSTALLATION** , Hose and Pipe.
16. Connect the fuel delivery hose (A) and evaporation hose (B).

NOTE: If fuel hoses or clamps are damaged, replace them with new parts.

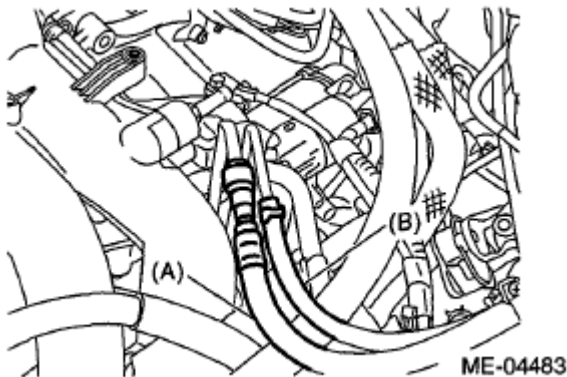


Fig. 62: Identifying Fuel Delivery Hose And Evaporation Hose
Courtesy of SUBARU OF AMERICA, INC.

17. Connect the torque converter clutch to the drive plate.
 1. Rotate the clank pulley to align the drive plate to the service hole, and tighten four bolts.

Tightening torque:

25 N.m (2.5 kgf-m, 18.4 ft-lb)

2. Install the service hole plug.

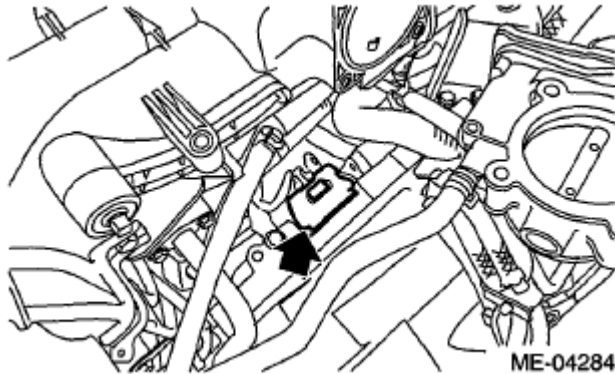


Fig. 63: Locating Service Hole Plug
Courtesy of SUBARU OF AMERICA, INC.

18. Remove the ST.

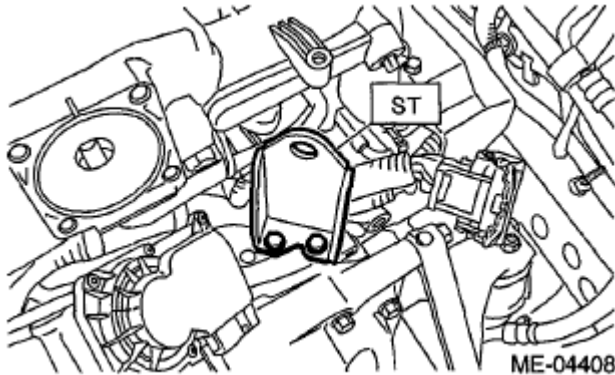


Fig. 64: Removing Throttle Body From Intake Manifold Using ST
Courtesy of SUBARU OF AMERICA, INC.

19. Install the throttle body to intake manifold.

NOTE: Use a new gasket.

Tightening torque:

8 N.m (0.8 kgf-m, 5.9 ft-lb)

20. Install the engine hanger bracket.

Tightening torque:

19 N.m (1.9 kgf-m, 14.0 ft-lb)

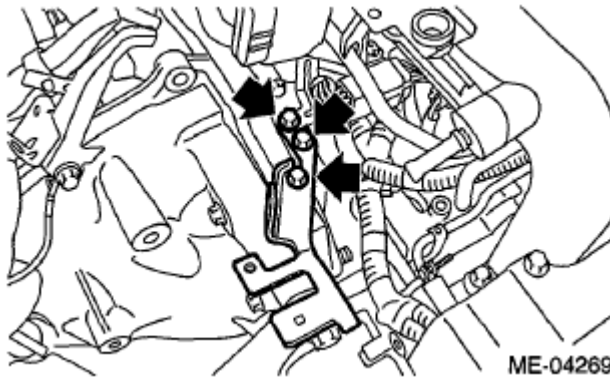


Fig. 65: Locating Engine Hanger Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

21. Install the engine harness connector to the engine hanger bracket.

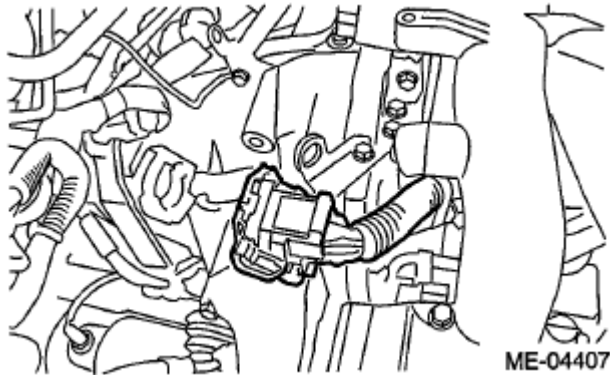


Fig. 66: Identifying Engine Harness Connector Of Engine Hanger Bracket
Courtesy of SUBARU OF AMERICA, INC.

22. Connect the connector to the throttle body.

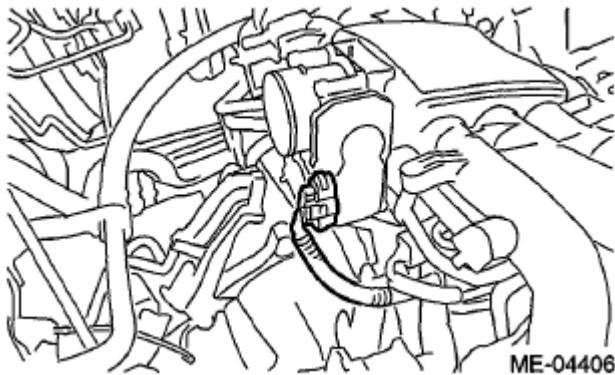


Fig. 67: Identifying Throttle Body Connector
Courtesy of SUBARU OF AMERICA, INC.

23. Connect the engine harness.

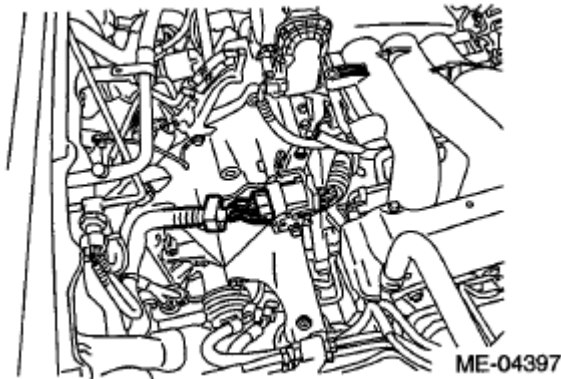


Fig. 68: Identifying Engine Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

24. Install the heater inlet hose and heater outlet hose.

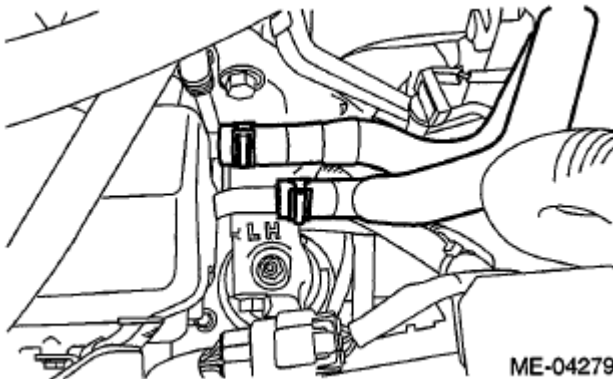


Fig. 69: Identifying Heater Inlet Hose And Heater Outlet Hose
Courtesy of SUBARU OF AMERICA, INC.

25. Attach the grille bracket.

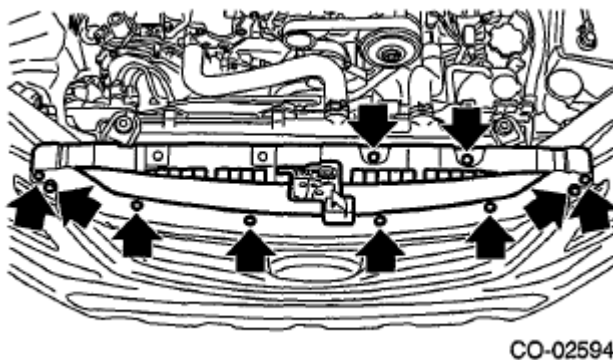


Fig. 70: Locating Grille Bracket Clips

Courtesy of SUBARU OF AMERICA, INC.

26. Install the starter. Ref. to **INSTALLATION** , Starter.
27. Install the starter harness and engine ground to the bracket.

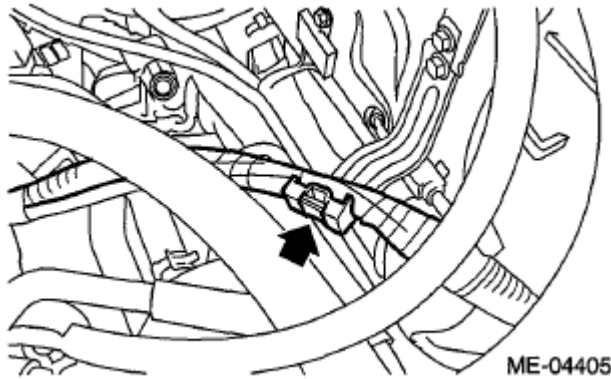


Fig. 71: Locating Starter Harness And Engine Ground
Courtesy of SUBARU OF AMERICA, INC.

28. Install the engine ground.

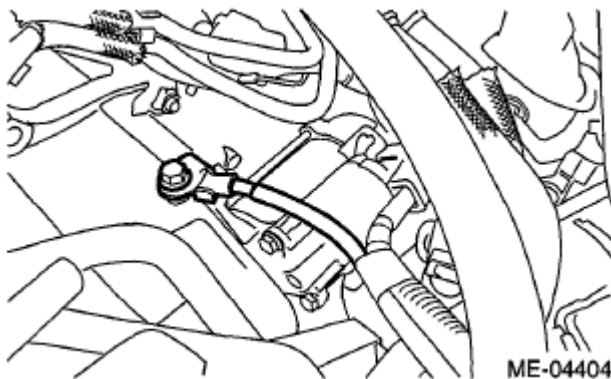


Fig. 72: Identifying Engine Ground
Courtesy of SUBARU OF AMERICA, INC.

29. Install the brake booster vacuum hose.

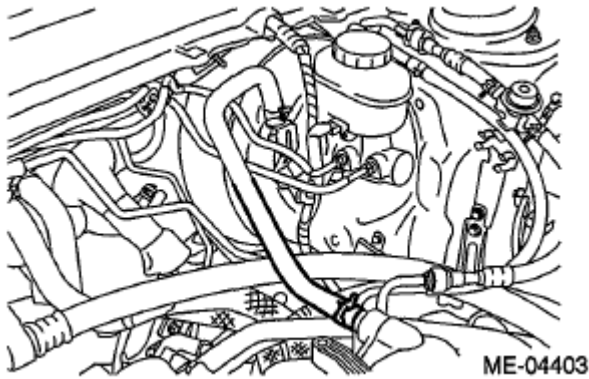


Fig. 73: Identifying Brake Booster Vacuum Hose
Courtesy of SUBARU OF AMERICA, INC.

30. Install the power steering pump together with the bracket.
 1. Install the power steering pump and power steering pump bracket to the cylinder block.
 2. Install the collector cover bracket and power steering pump bracket.

Tightening torque:

T1: 6.4 N.m (0.7 kgf-m, 4.7 ft-lb)

T2: 25 N.m (2.5 kgf-m, 18.4 ft-lb)

T3: 33 N.m (3.4 kgf-m, 24.3 ft-lb)

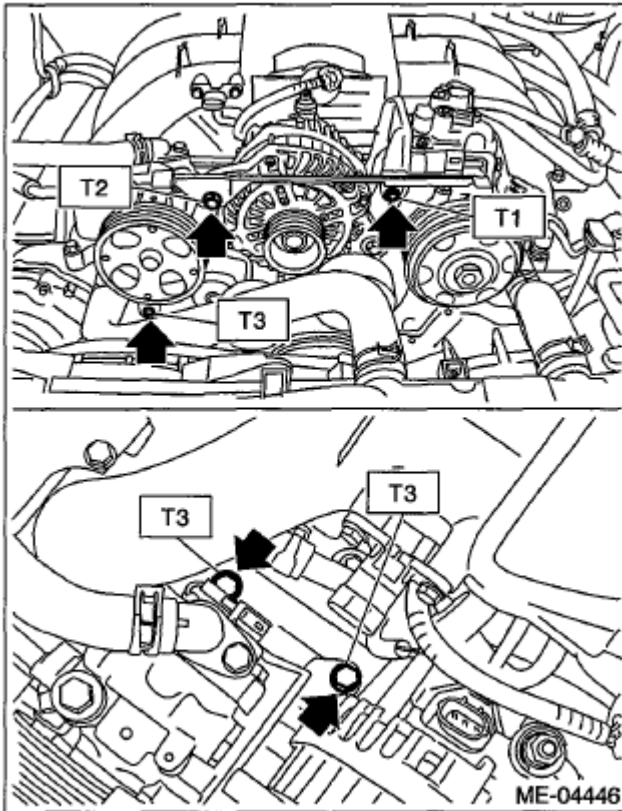


Fig. 74: Locating Power Steering Pump Bolts
Courtesy of SUBARU OF AMERICA, INC.

3. Connect the manifold absolute pressure sensor connector (A) and power steering pump connector (B).

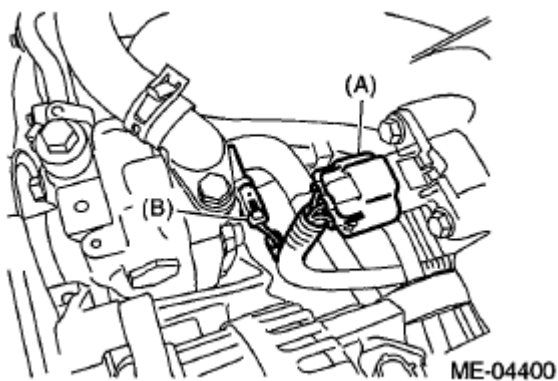


Fig. 75: Identifying Manifold Absolute Pressure Sensor Connector And Power Steering Pump Connector
Courtesy of SUBARU OF AMERICA, INC.

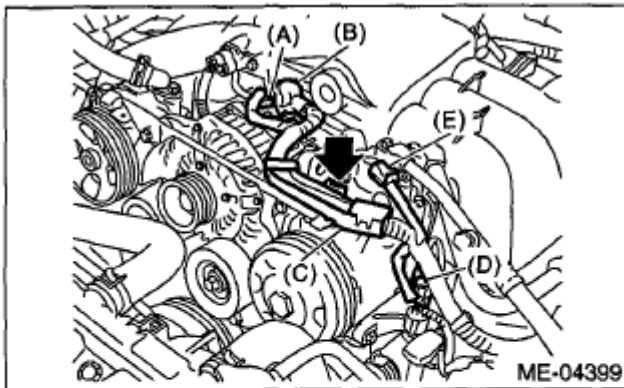
31. Connect the following connectors.
 1. Generator connector

2. Generator terminal B

Tightening torque:

16 N.m (1.6 kgf-m, 11.8 ft-lb)

3. Install the harness cover to the collector cover bracket.
4. A/C compressor solenoid connector
5. Flow sensor connector



- (A) Generator connector
- (B) Generator terminal B
- (C) Install the harness cover to the collector cover bracket.
- (D) A/C compressor solenoid connector
- (E) Flow sensor connector

Fig. 76: Identifying Generator Connector, Terminal B, Harness Cover, Flow Sensor Connector

Courtesy of SUBARU OF AMERICA, INC.

6. Install with the securing clips to the two locations on the fuel pipe protector (LH).

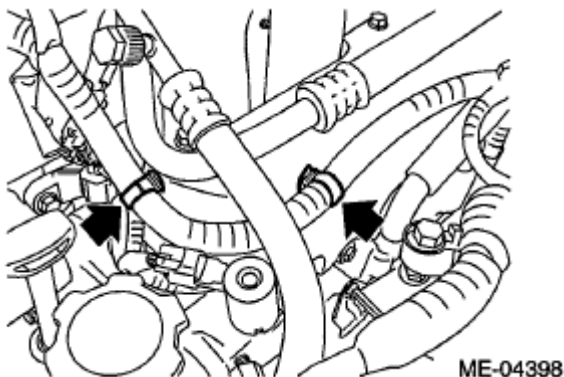


Fig. 77: Locating Fuel Pipe Protector (LH) Clips
Courtesy of SUBARU OF AMERICA, INC.

32. Install the V-belts. Ref. to **INSTALLATION**, V-belt.
33. Install the air intake duct, air cleaner case and air intake boot assembly. Ref. to **INSTALLATION**, Air Intake Duct. Ref. to **INSTALLATION**, Air Cleaner Case. Ref. to **INSTALLATION**, Air Intake Boot.
34. Connect the ground cable to battery.
35. Fill engine coolant. Ref. to **FILLING OF ENGINE COOLANT**, REPLACEMENT, Engine Coolant.
36. Charge the A/C system with refrigerant. Ref. to **PROCEDURE**, Refrigerant Charging Procedure.
37. Check the ATF level and replenish it if necessary. Ref. to **INSPECTION**, Automatic Transmission Fluid.
38. Install the collector cover.
39. Change the front hood damper bolt mounting position from (B) to (A), and completely close the front hood.

Tightening torque:

20 N.m (2.0 kgf-m, 14.8 ft-lb)

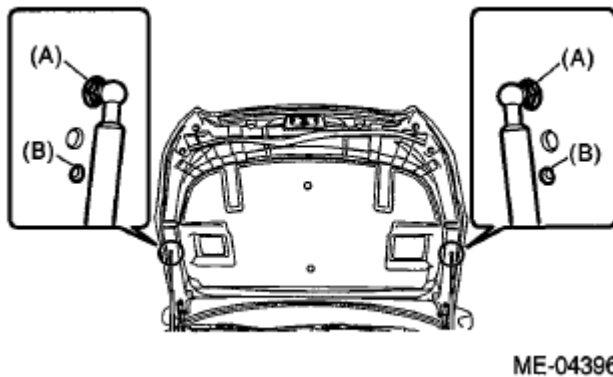


Fig. 78: Identifying Front Hood Damper Bolt Mounting Position
Courtesy of SUBARU OF AMERICA, INC.

INSPECTION

1. Check that the pipes, hoses, connectors and clips are securely connected.
2. Check that the engine coolant is up to specified level.
3. Check that the ATF is up to specified level.
4. Start the engine and check for exhaust gas, engine coolant, leaks of fuel, etc. Also check for noise and vibrations.

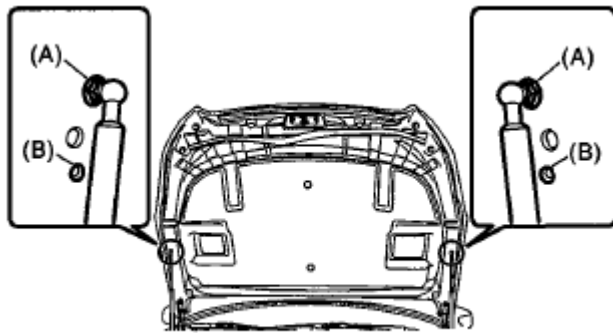
ENGINE MOUNTING

REMOVAL

1. Change the front hood damper bolt mounting position from (A) to (B), and completely open the front hood.

Tightening torque:

20 N.m (2.0 kgf-m, 14.8 ft-lb)



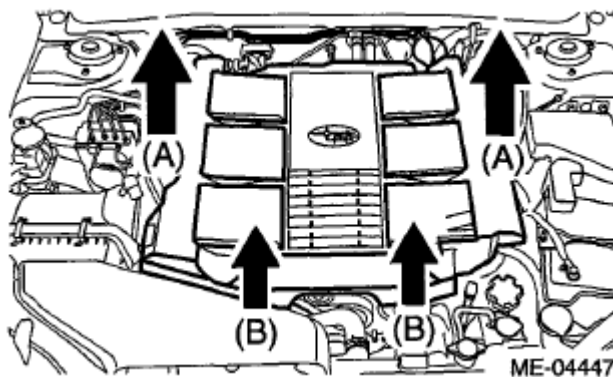
ME-04396

Fig. 79: Identifying Front Hood Damper Bolt Mounting Position
 Courtesy of SUBARU OF AMERICA, INC.

2. Remove the collector cover.

NOTE: Follow these procedures for removal of the collector cover.

1. Lift up the rear side holding two positions (A).
2. Lift up the front side holding two positions (B) while moving it in the forward direction of the vehicle.



ME-04447

Fig. 80: Locating Front And Rear Side Holding Position
 Courtesy of SUBARU OF AMERICA, INC.

3. Remove the air intake duct, air cleaner case and air intake boot assembly. Ref. to **REMOVAL** , Air Intake Duct. Ref. to **REMOVAL** , Air Cleaner Case. Ref. to **REMOVAL** , Air Intake Boot.

4. Remove the grille bracket.

NOTE: Remove ten clips when removing the grille bracket.

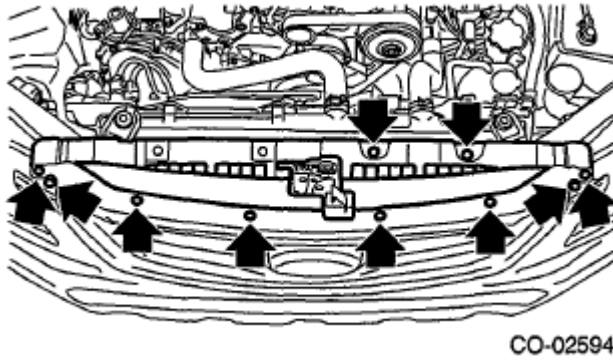


Fig. 81: Locating Grille Bracket Clips
Courtesy of SUBARU OF AMERICA, INC.

5. Lift up the vehicle.
6. Remove the under cover. Ref. to **REMOVAL** , Front Under Cover.
7. Drain engine coolant completely. Ref. to **DRAINING OF ENGINE COOLANT** , REPLACEMENT, Engine Coolant.
8. Lower the vehicle.
9. Remove the radiator main fan & fan motor and radiator sub fan & fan motor. Ref. to **REMOVAL** , Radiator Main Fan and Fan Motor. Ref. to **REMOVAL** , Radiator Sub Fan and Fan Motor.
10. Disconnect the engine harness.

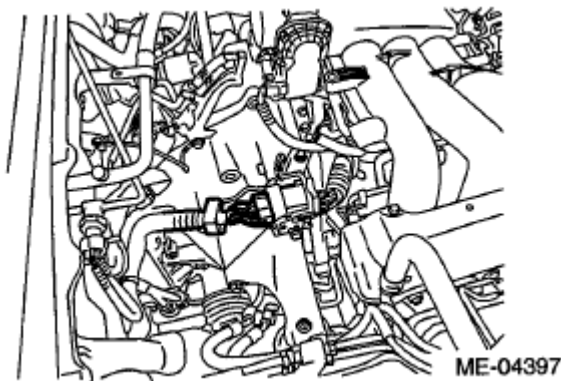


Fig. 82: Identifying Engine Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

11. Disconnect the connector from the throttle body.

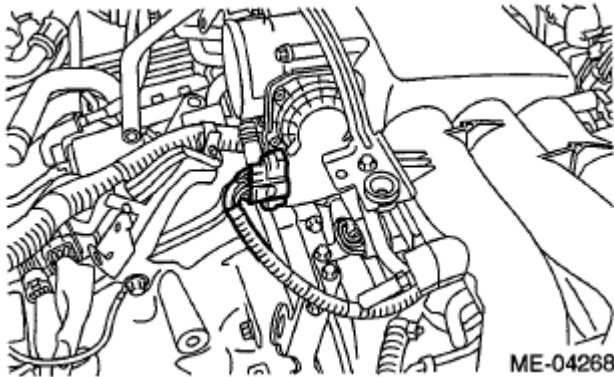


Fig. 83: Identifying Throttle Body Connector
Courtesy of SUBARU OF AMERICA, INC.

12. Remove the engine harness connector from the engine hanger bracket.

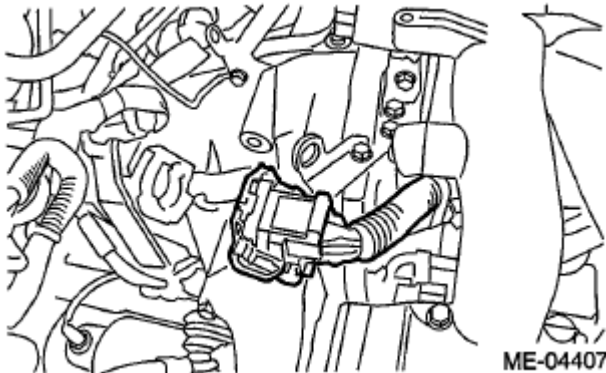


Fig. 84: Identifying Engine Harness Connector Of Engine Hanger Bracket
Courtesy of SUBARU OF AMERICA, INC.

13. Remove the engine hanger bracket.

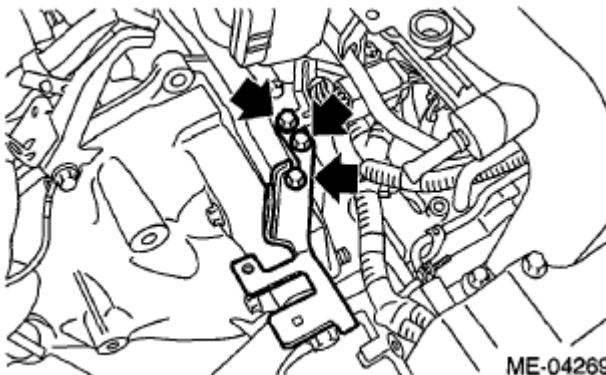


Fig. 85: Locating Engine Hanger Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

14. Remove the throttle body from the intake manifold.

NOTE: Do not disconnect the inlet and outlet hoses of engine coolant.

15. Attach the ST.

ST 18360AA020 HANGER

Tightening torque:

19 N.m (1.9 kgf-m, 14.0 ft-lb)

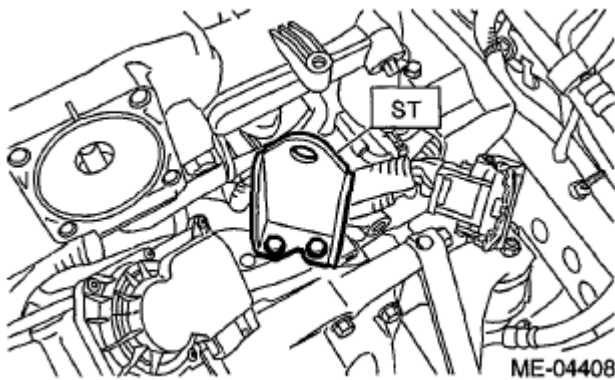


Fig. 86: Removing Throttle Body From Intake Manifold Using ST
Courtesy of SUBARU OF AMERICA, INC.

16. Support the engine with a lifting device and wire ropes.

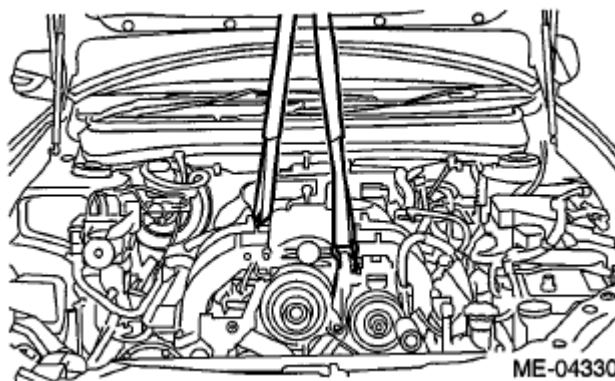


Fig. 87: Supporting Engine With Lifting Device And Wire Ropes
Courtesy of SUBARU OF AMERICA, INC.

17. Remove the front mount.

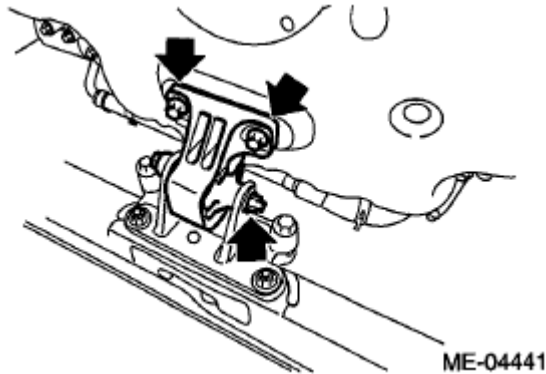


Fig. 88: Locating Front Mount
Courtesy of SUBARU OF AMERICA, INC.

18. Remove the front mounting bracket from the cradle.

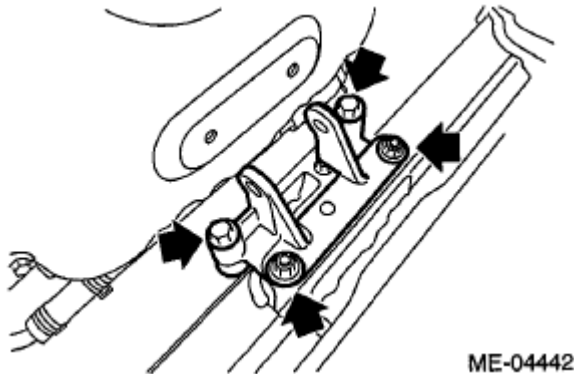


Fig. 89: Locating Front Mounting Bracket Of Cradle
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

1. Install front mounting bracket to the cradle.

Tightening torque:

60 N.m (6.1 kgf-m, 44.3 ft-lb)

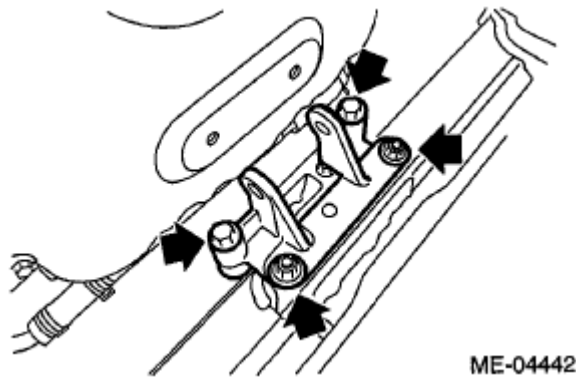


Fig. 90: Locating Front Mounting Bracket Of Cradle
Courtesy of SUBARU OF AMERICA, INC.

2. Install the front mount.

Tightening torque:

T1: 25 N.m (2.5 kgf-m, 18.4 ft-lb)

T2: 45 N.m (4.6 kgf-m, 33.2 ft-lb)

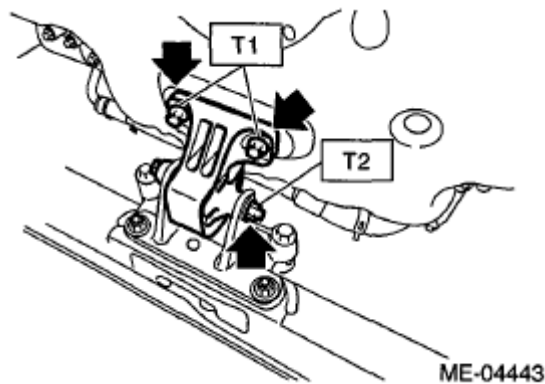


Fig. 91: Locating Front Mount
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the lifting device and wire ropes.

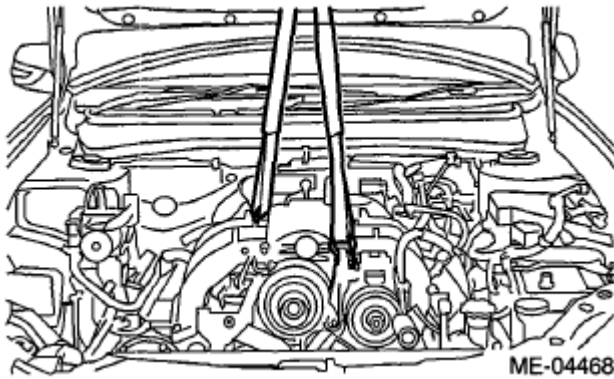


Fig. 92: Supporting Engine With Lifting Device And Wire Ropes
Courtesy of SUBARU OF AMERICA, INC.

4. Install the radiator main fan & fan motor and radiator sub fan & fan motor. Ref. to **INSTALLATION** , Radiator Main Fan and Fan Motor. Ref. to **INSTALLATION** , Radiator Sub Fan and Fan Motor.
5. Lift up the vehicle.
6. Install the under cover. Ref. to **INSTALLATION** , Front Under Cover.
7. Lower the vehicle.
8. Remove the ST.

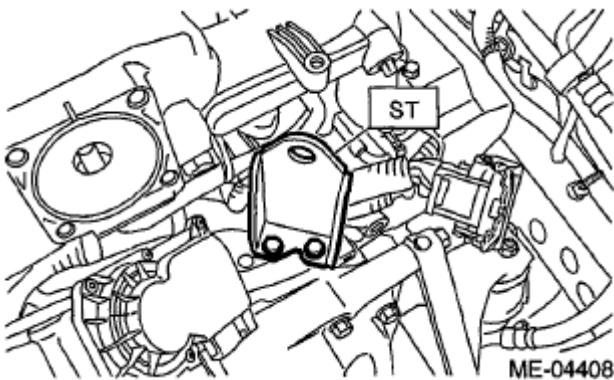


Fig. 93: Removing Throttle Body From Intake Manifold Using ST
Courtesy of SUBARU OF AMERICA, INC.

9. Install the throttle body to intake manifold.

NOTE: **Use a new gasket.**

Tightening torque:

8 N.m (0.8 kgf-m, 5.9 ft-lb)

10. Install the engine hanger bracket.

Tightening torque:

19 N.m (1.9 kgf-m, 14.0 ft-lb)

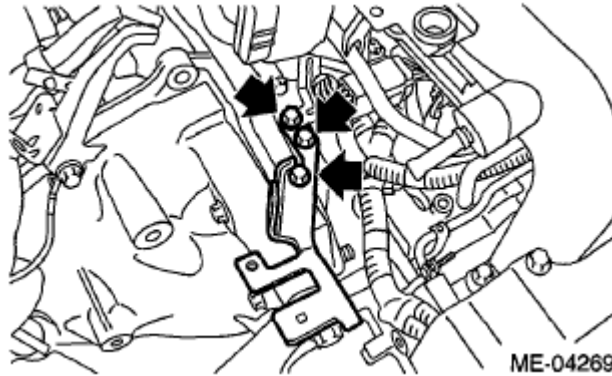


Fig. 94: Locating Engine Hanger Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

11. Install the engine harness connector to the engine hanger bracket.

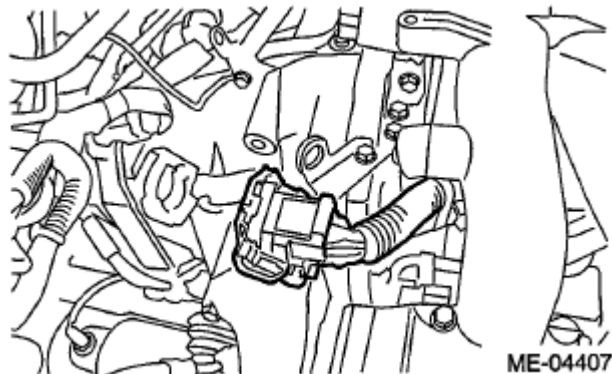


Fig. 95: Identifying Engine Harness Connector Of Engine Hanger Bracket
Courtesy of SUBARU OF AMERICA, INC.

12. Connect the connector to the throttle body.

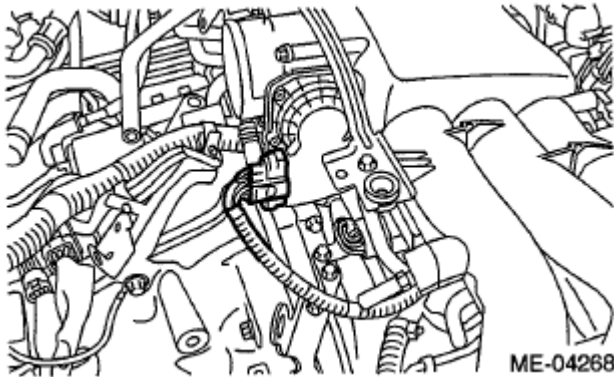


Fig. 96: Identifying Throttle Body Connector
Courtesy of SUBARU OF AMERICA, INC.

13. Connect the engine harness.

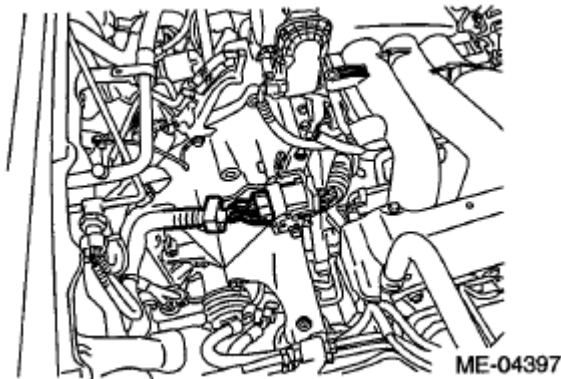


Fig. 97: Identifying Engine Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

14. Attach the grille bracket.

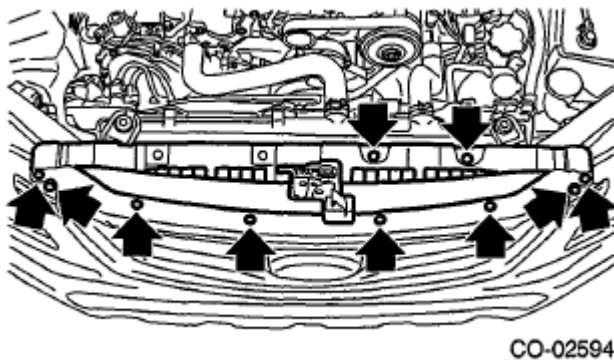


Fig. 98: Locating Grille Bracket Clips
Courtesy of SUBARU OF AMERICA, INC.

15. Install the air intake duct, air cleaner case and air intake boot assembly. Ref. to **INSTALLATION** , Air Intake Duct. Ref. to **INSTALLATION** , Air Cleaner Case. Ref. to **INSTALLATION** , Air Intake Boot.
16. Connect the ground cable to battery.
17. Fill engine coolant. Ref. to **FILLING OF ENGINE COOLANT** , REPLACEMENT, Engine Coolant.
18. Install the collector cover.
19. Change the front hood damper bolt mounting position from (B) to (A), and completely close the front hood.

Tightening torque:

20 N.m (2.0 kgf-m, 14.8 ft-lb)

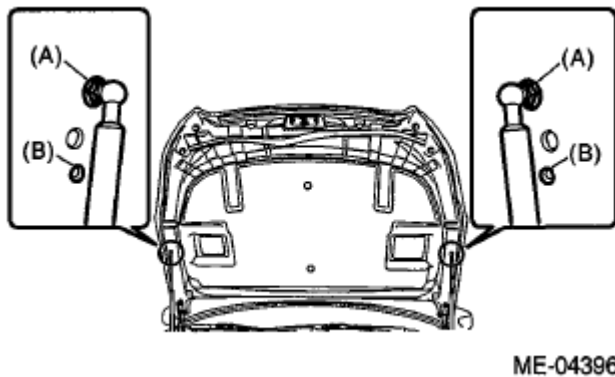


Fig. 99: Identifying Front Hood Damper Bolt Mounting Position
Courtesy of SUBARU OF AMERICA, INC.

INSPECTION

Check that the front mount and front mount bracket have no deformation, cracks and other damages.

PREPARATION FOR OVERHAUL**REMOVAL**

1. Remove the engine assembly from the body. Ref. to **REMOVAL**, Engine Assembly.
2. Set the engine on ST.

ST 18232AA000 ENGINE STAND

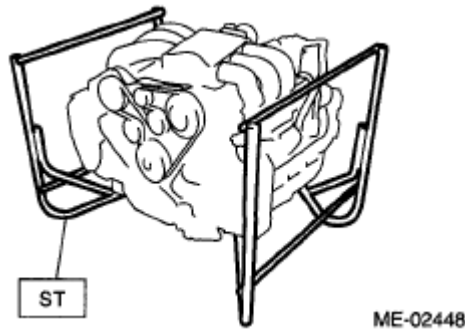


Fig. 100: Setting Engine On ST
Courtesy of SUBARU OF AMERICA, INC.

3. Before servicing overhaul, remove the sensor, pipe and hose that installed to engine.
 1. Remove the intake manifold. Ref. to **REMOVAL** , Intake Manifold.
 2. Remove the generator. Ref. to **REMOVAL** , Generator.
 3. Remove the A/C compressor. Ref. to **REMOVAL** , Compressor.
 4. Disconnect the water pipe and hose.
 5. Disconnect the engine harness.
 6. Remove the spark plug. Ref. to **REMOVAL** , Spark Plug.
 7. Remove the camshaft position sensor. Ref. to **REMOVAL** , Camshaft Position Sensor.
 8. Remove the crankshaft position sensor. Ref. to **REMOVAL** , Crankshaft Position Sensor.
 9. Remove the knock sensor. Ref. to **REMOVAL** , Knock Sensor.
 10. Remove the engine coolant temperature sensor. Ref. to **REMOVAL** , Engine Coolant Temperature Sensor.
 11. Remove the oil temperature sensor. Ref. to **REMOVAL** , Oil Temperature Sensor.
 12. Remove the oil flow control solenoid valve. Ref. to **REMOVAL** , Oil Flow Control Solenoid Valve.
 13. Remove the oil pressure switch. Ref. to **REMOVAL** , Oil Pressure Switch.
 14. Remove the oil filter. Ref. to **REMOVAL** , Engine Oil Filter.
 15. Remove the oil cooler. Ref. to **REMOVAL** , Oil Cooler.

V-BELT

REMOVAL

NOTE: When replacing the single part, perform the work with the engine installed to body.

1. Remove the collector cover.

NOTE: Follow these procedures for removal of the collector cover.

1. Lift up the rear side holding two positions (A).
2. Lift up the front side holding two positions (B) while moving it in the forward direction of the vehicle.

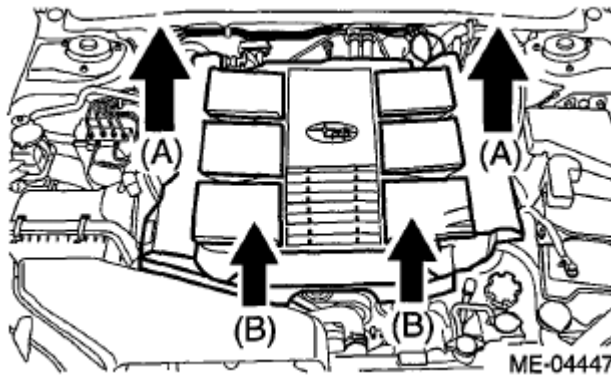


Fig. 101: Locating Front And Rear Side Holding Position
 Courtesy of SUBARU OF AMERICA, INC.

2. Remove the air intake duct. Ref. to **REMOVAL** , Air Intake Duct.
3. Install the tool to the pulley bolt of the belt tension adjuster assembly.
4. Rotate the tool clockwise and loosen the V-belt to remove.

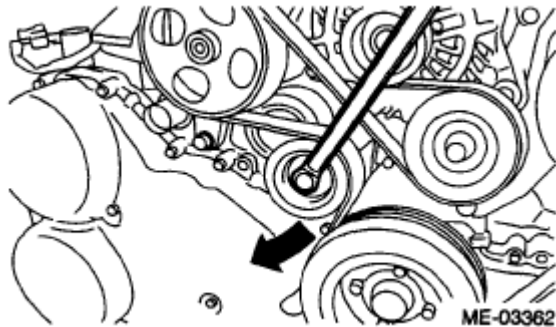
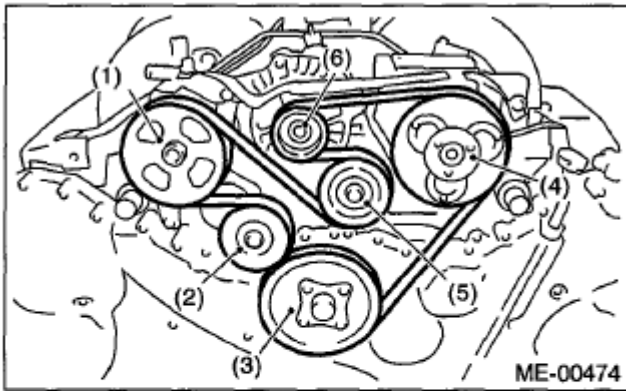


Fig. 102: Loosening V-Belt
 Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

Install in the reverse order of removal.



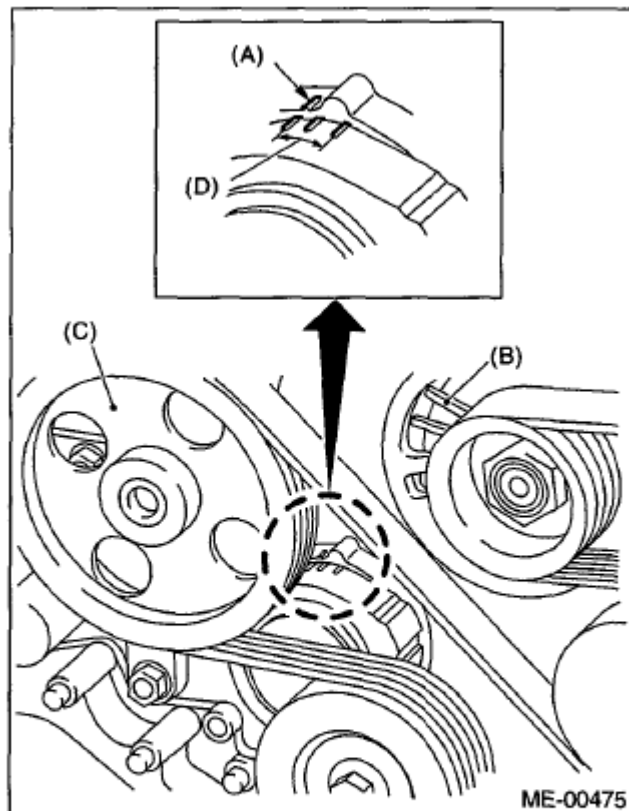
- (1) Power steering oil pump pulley
- (2) Belt tension adjuster ASSY
- (3) Crank pulley
- (4) A/C compressor pulley
- (5) Belt idler
- (6) Generator

Fig. 103: V-Belt Routing Diagram

Courtesy of SUBARU OF AMERICA, INC.

INSPECTION

1. Replace the V-belt, if cracks, fraying or wear is found.
2. Make sure that the V-belt automatic belt tension indicator (A) is within the range (D).



- (A) Indicator
- (B) Generator
- (C) Power steering oil pump pulley
- (D) Service limit

Fig. 104: Identifying V-Belt Automatic Belt Tension Indicator Range
Courtesy of SUBARU OF AMERICA, INC.

CRANK PULLEY

REMOVAL

NOTE: When replacing the single part, perform the work with the engine installed to body.

1. Remove the V-belts. Ref. to **REMOVAL**, V-belt.
2. Remove the crank pulley cover.

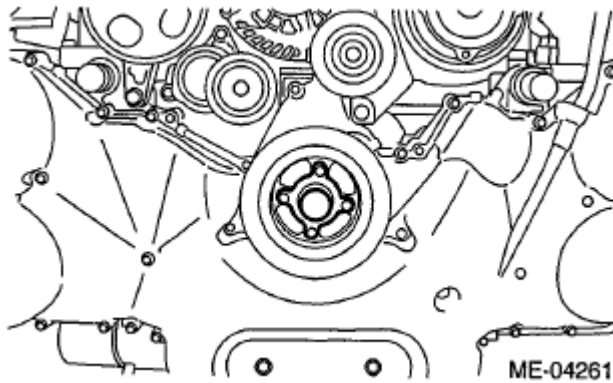


Fig. 105: Identifying Crank Pulley Cover
Courtesy of SUBARU OF AMERICA, INC.

3. Use the ST to lock the crank pulley, and remove the crank pulley bolt.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET

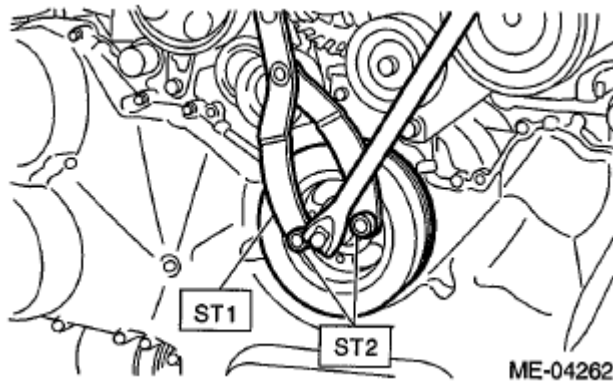


Fig. 106: Removing Crank Pulley Bolt Using ST
Courtesy of SUBARU OF AMERICA, INC.

4. Remove the crank pulley.

INSTALLATION

1. Clean the crankshaft thread using compressed air.
2. Install the crank pulley.
3. Apply engine oil to the crank pulley bolt seat and thread.
4. Use the ST to lock the crank pulley, and tighten the crank pulley bolt.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET

Tightening torque:

195 N.m (19.9 kgf-m, 143.8 ft-lb)

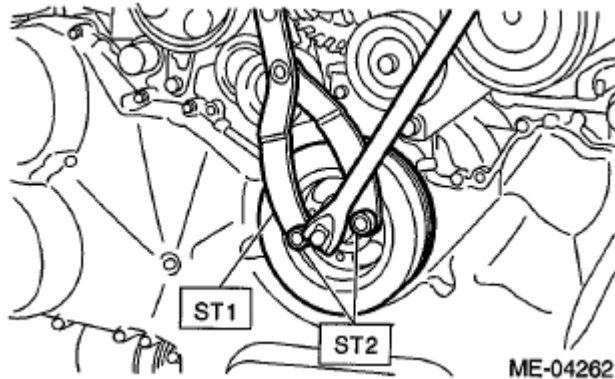


Fig. 107: Removing Crank Pulley Bolt Using ST
Courtesy of SUBARU OF AMERICA, INC.

5. Install the O-ring, and install the crank pulley cover.

NOTE: Use new O-rings.

Tightening torque:

6.4 N.m (0.7 kgf-m, 4.7 ft-lb)

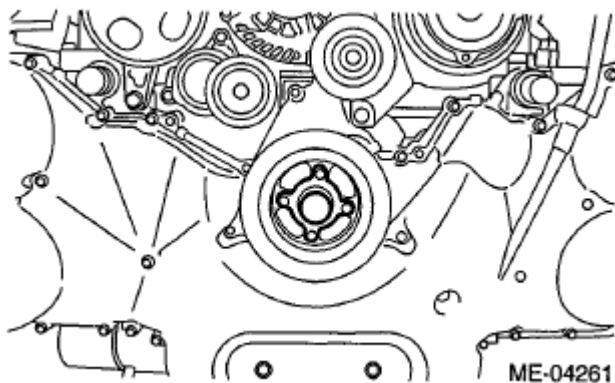


Fig. 108: Identifying Crank Pulley Cover
Courtesy of SUBARU OF AMERICA, INC.

6. Install the V-belts. Ref. to **INSTALLATION**, V-belt.

INSPECTION

1. Check for oil leaks in the crank pulley cover.
2. Check the crank pulley for looseness.

CHAIN COVER

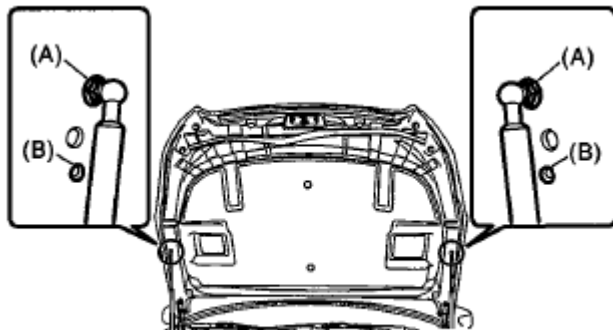
REMOVAL

NOTE: When replacing the single part, perform the work with the engine installed to body.

1. Drain the engine oil. Ref. to REPLACEMENT , Engine Oil.
2. Lift up the vehicle.
3. Remove the under cover. Ref. to REMOVAL , Front Under Cover.
4. Drain engine coolant. Ref. to DRAINING OF ENGINE COOLANT , REPLACEMENT, Engine Coolant.
5. Remove the front exhaust pipe. Ref. to REMOVAL , Front Exhaust Pipe.
6. Lower the vehicle.
7. Change the bolt mounting position from (A) to (B), and completely open the front hood.

Tightening torque:

20 N.m (2.0 kgf-m, 14.8 ft-lb)



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Fig. 109: Identifying Front Hood Damper Bolt Mounting Position
Courtesy of SUBARU OF AMERICA, INC.

8. Remove the air intake duct. Ref. to REMOVAL , Air Intake Duct.
9. Remove the air intake boot assembly. Ref. to REMOVAL , Air Intake Boot.
10. Disconnect the engine harness connector.

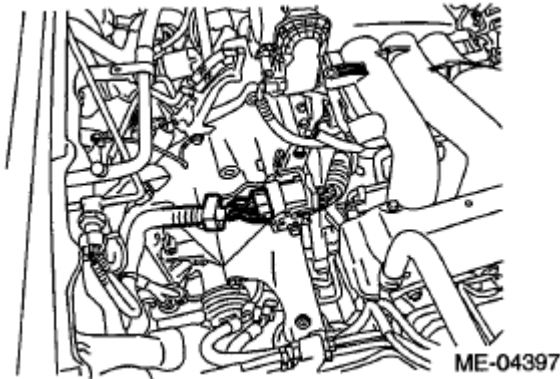


Fig. 110: Identifying Engine Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

11. Disconnect the connector from the throttle body.

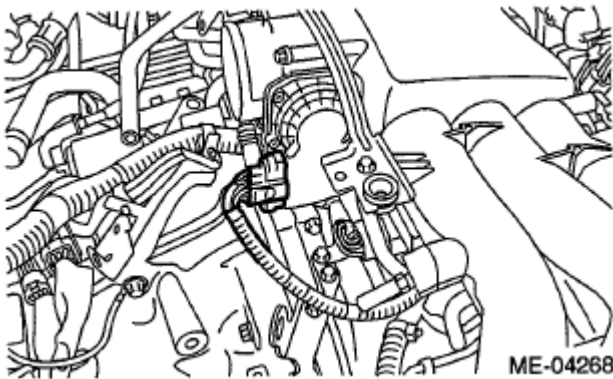


Fig. 111: Identifying Throttle Body Connector
Courtesy of SUBARU OF AMERICA, INC.

12. Remove the engine harness connector from the engine hanger bracket.

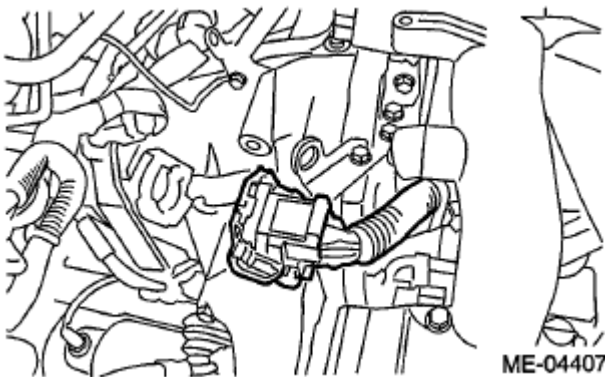


Fig. 112: Identifying Engine Harness Connector Of Engine Hanger Bracket
Courtesy of SUBARU OF AMERICA, INC.

13. Remove the engine hanger bracket.

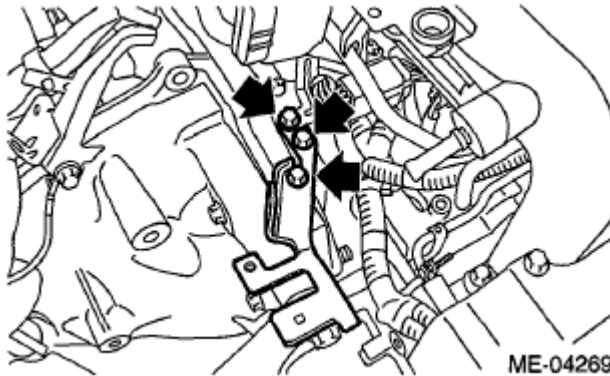


Fig. 113: Locating Engine Hanger Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

14. Remove the throttle body from the intake manifold.

NOTE: Do not disconnect the inlet and outlet hoses of engine coolant.

15. Attach the ST.

ST 18360AA020 HANGER

Tightening torque:

19 N.m (1.9 kgf-m, 14.0 Mb)

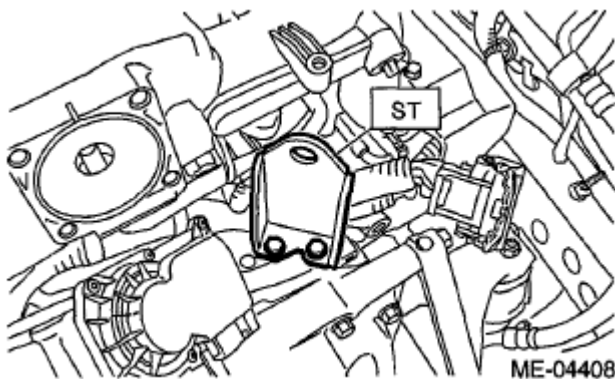


Fig. 114: Removing Throttle Body From Intake Manifold Using ST
Courtesy of SUBARU OF AMERICA, INC.

16. Remove the V-belts. Ref. to **REMOVAL**, V-belt.
17. Remove the crank pulley. Ref. to **REMOVAL**, Crank Pulley.
18. Remove the grille bracket.

NOTE: Remove ten clips when removing the grille bracket.

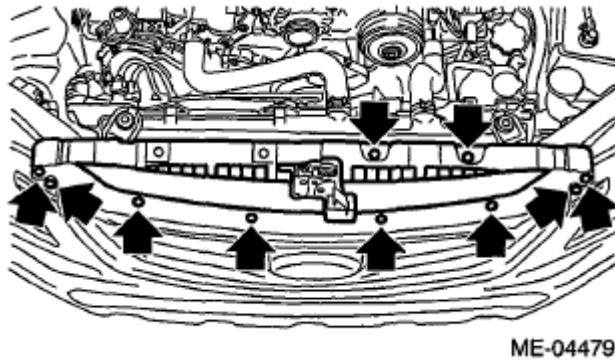


Fig. 115: Locating Grille Bracket Clips
Courtesy of SUBARU OF AMERICA, INC.

19. Remove the reservoir tank. Ref. to **REMOVAL** , Reservoir Tank.
20. Remove the radiator main fan & fan motor and radiator sub fan & fan motor. Ref. to **REMOVAL** , Radiator Main Fan and Fan Motor.
21. Remove the radiator. Ref. to **REMOVAL** , Radiator.
22. Support the engine with a lifting device and wire ropes.
23. Remove the front mount from the chain cover.

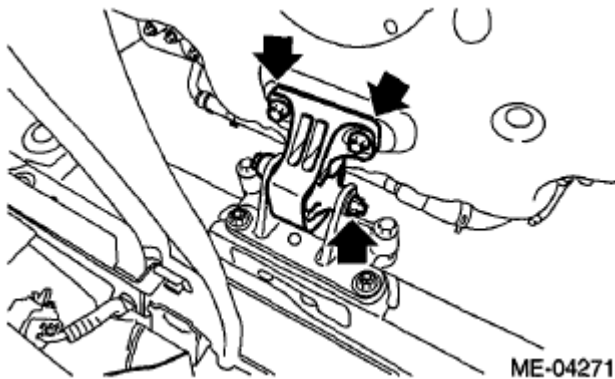


Fig. 116: Locating Front Mount
Courtesy of SUBARU OF AMERICA, INC.

24. Remove the front mounting bracket from the cradle.

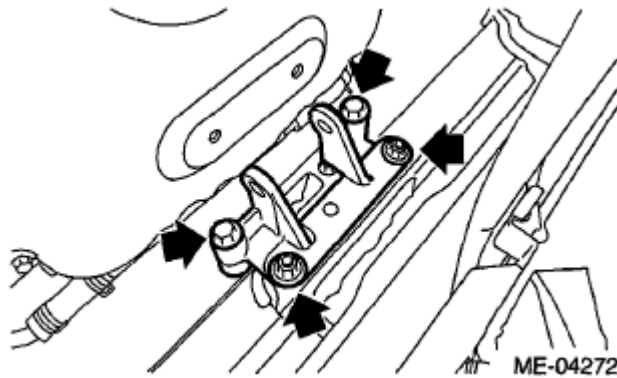


Fig. 117: Locating Front Mounting Bracket Of Cradle
Courtesy of SUBARU OF AMERICA, INC.

25. Remove the oil cooler pipe from the chain cover.

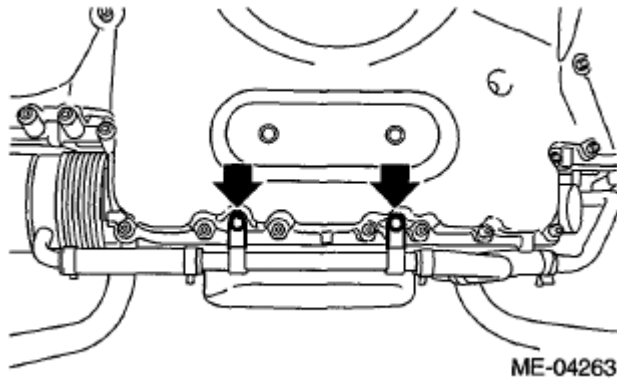


Fig. 118: Locating Oil Cooler Pipe Bolts
Courtesy of SUBARU OF AMERICA, INC.

26. Remove the chain cover.

NOTE: Chain cover installation bolt has three different sizes. To prevent the confusion in installation, keep these bolts on container individually.

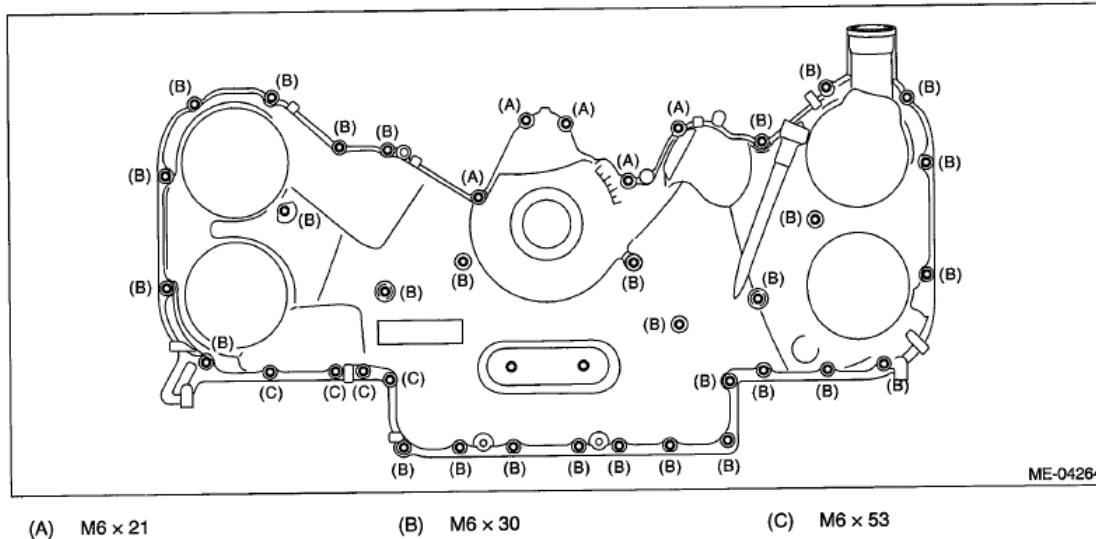


Fig. 119: Identifying Chain Cover Bolts
 Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

1. Apply liquid gasket to the mating surfaces of the cylinder block, cylinder head and oil pan upper as shown in the figure.

Liquid gasket:

THREE BOND 1217G (Part No. K0877Y0100) or equivalent

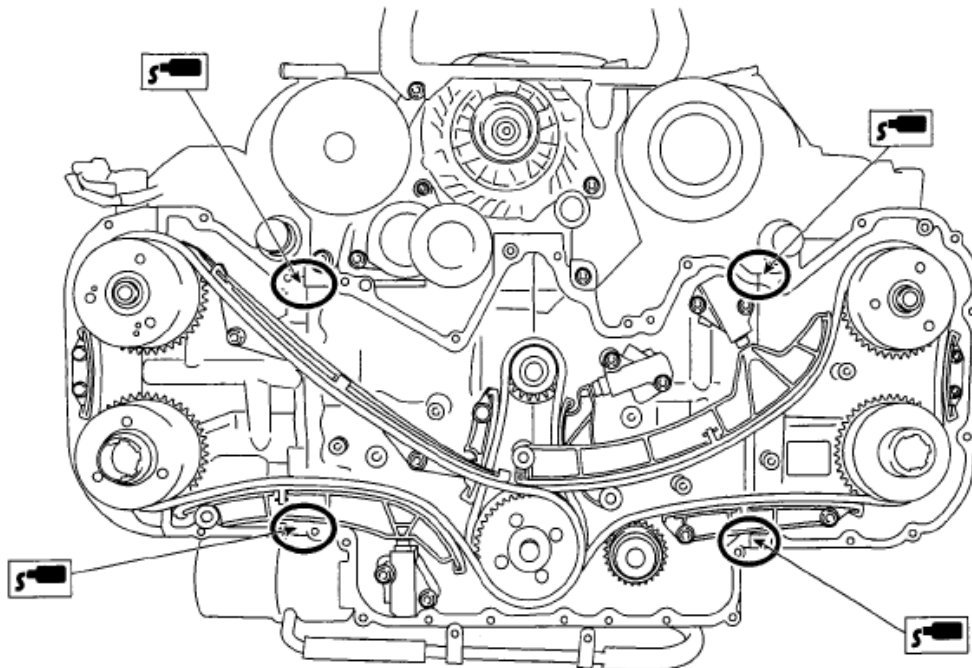


Fig. 120: Identifying Liquid Gasket Applying Area On Cylinder Block, Cylinder Head And Oil Pan Upper
Courtesy of SUBARU OF AMERICA, INC.

2. Apply liquid gasket to the mating surface of the chain cover.

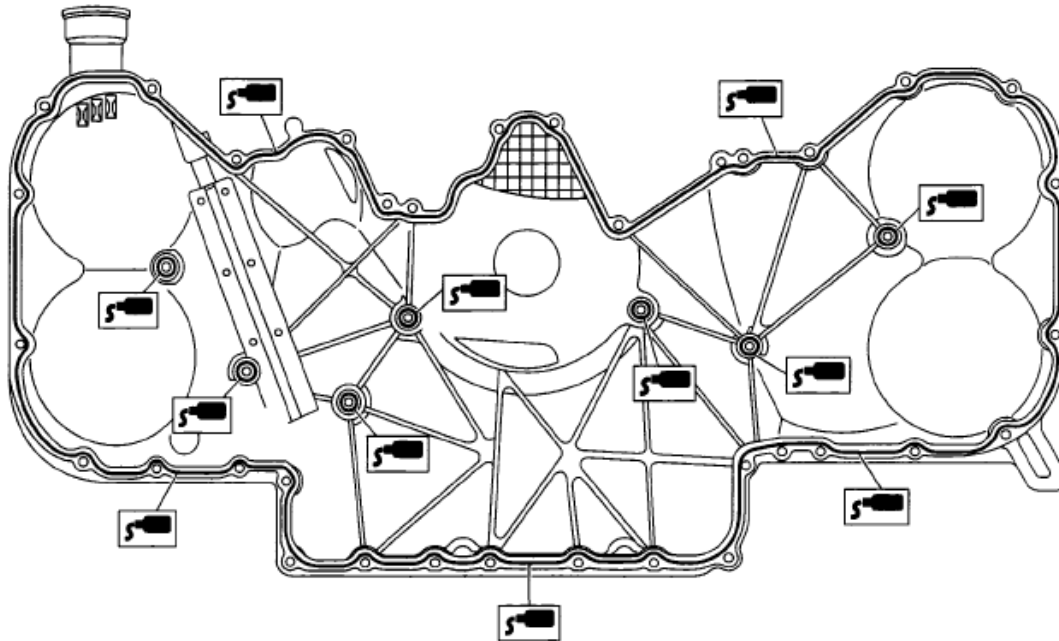
NOTE: Install within 5 min. after applying liquid gasket.

Liquid gasket:

THREE BOND 1217G (Part No. K0877Y0100) or equivalent

Liquid gasket applying diameter:

$3.5 \pm 0.5 \text{ mm}$ ($0.138 \pm 0.020 \text{ in}$)



ME-03545

Fig. 121: Identifying Liquid Gasket Applying Area On Chain Cover
Courtesy of SUBARU OF AMERICA, INC.

3. Attach the chain cover and temporarily tighten the chain cover installation bolts.

CAUTION: Do not install the chain cover installation bolts in wrong place.

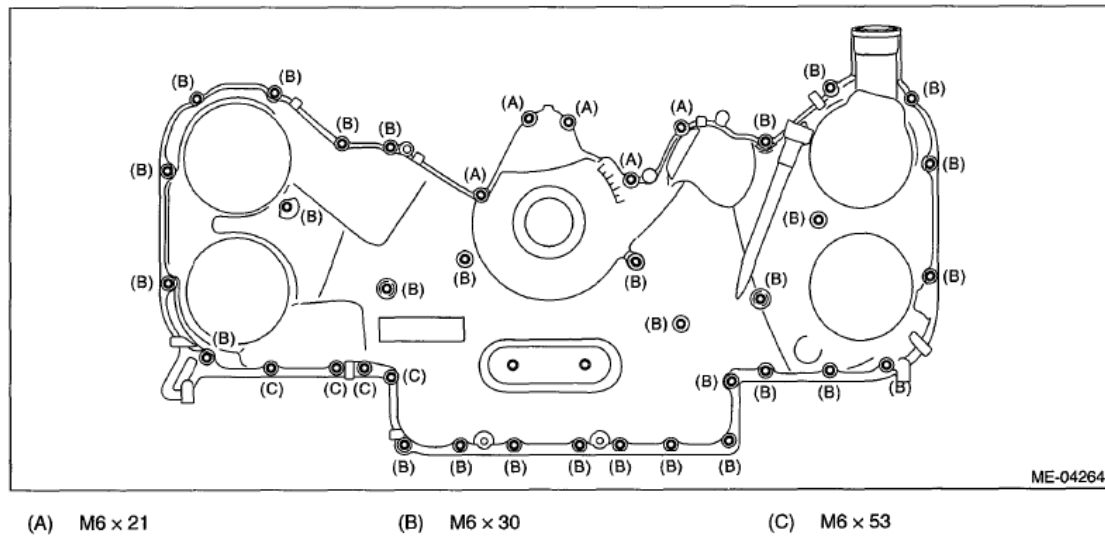


Fig. 122: Identifying Chain Cover Bolts
Courtesy of SUBARU OF AMERICA, INC.

4. Tighten the chain cover installing bolts in the numerical order as shown in the figure.

Tightening torque:

10 N.m (1.0 kgf-m, 7.4 ft-lb)

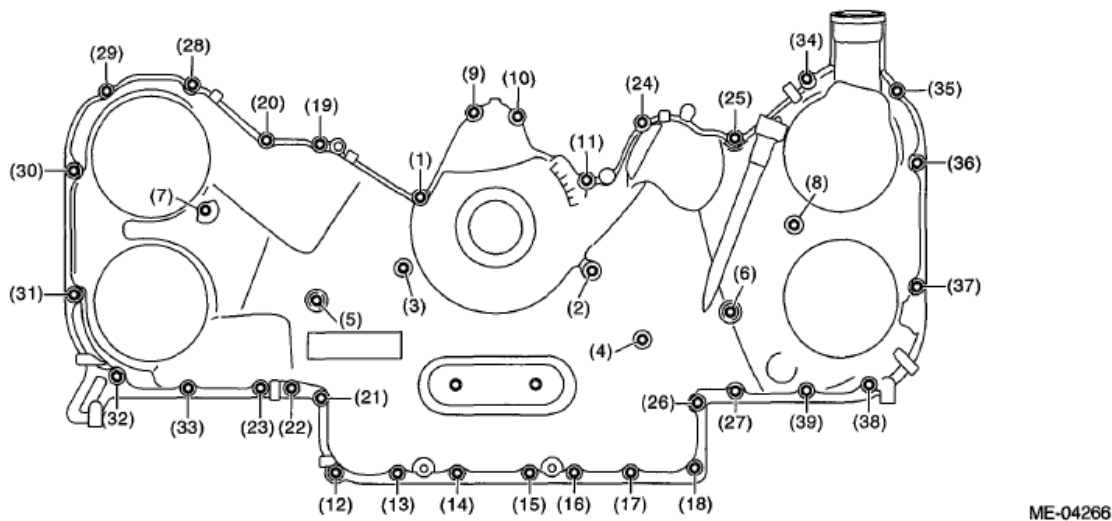


Fig. 123: Identifying Chain Cover Bolts In Tightening Order
Courtesy of SUBARU OF AMERICA, INC.

5. Install the oil cooler pipe to the chain cover.

Tightening torque:

6.4 N.m (0.7 kgf-m, 4.7 ft-lb)

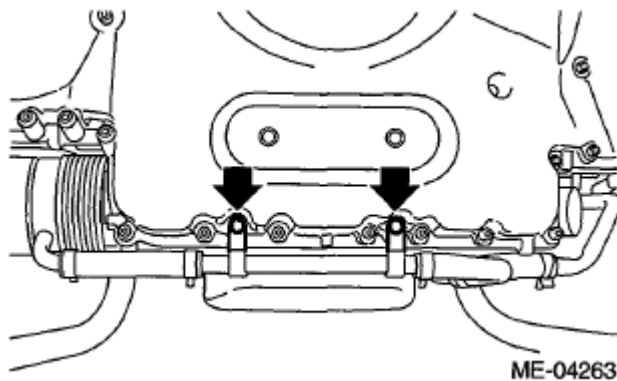


Fig. 124: Locating Oil Cooler Pipe Bolts
Courtesy of SUBARU OF AMERICA, INC.

6. Install front mounting bracket to the cradle.

Tightening torque:

60 N.m (6.1 kgf-m, 44.3 ft-lb)

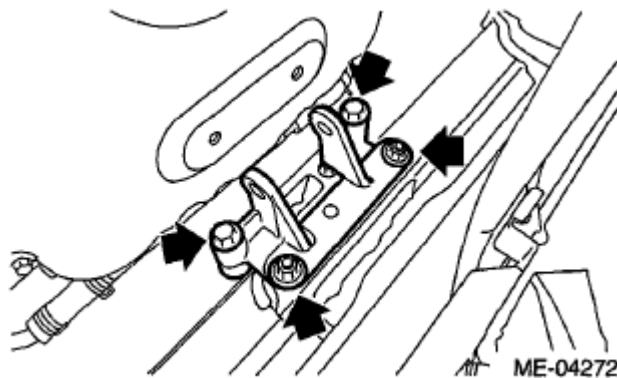


Fig. 125: Locating Front Mounting Bracket Of Cradle
Courtesy of SUBARU OF AMERICA, INC.

7. Install the front mount.

Tightening torque:

T1: 25 N.m (2.5 kgf-m, 18.4 ft-lb)

T2: 45 N.m (4.6 kgf-m, 33.2 ft-lb)

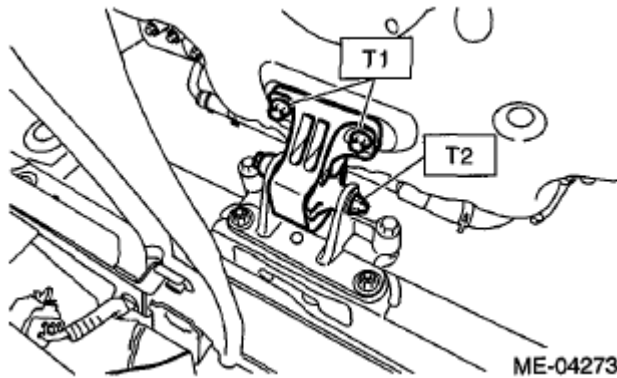


Fig. 126: Identifying Front Mount With Torque Specification
 Courtesy of SUBARU OF AMERICA, INC.

8. Remove the lifting device and wire ropes.
9. Install the radiator. Ref. to **INSTALLATION** , Radiator.
10. Install the radiator main & fan motor and radiator sub fan & fan motor. Ref. to **INSTALLATION** , Radiator Main Fan and Fan Motor.
11. Install the reservoir tank. Ref. to **INSTALLATION** , Reservoir Tank.
12. Attach the grille bracket.

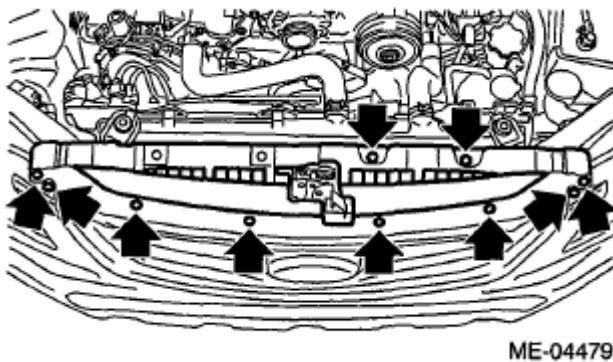


Fig. 127: Locating Grille Bracket Clips
 Courtesy of SUBARU OF AMERICA, INC.

13. Install the crank pulley. Ref. to **INSTALLATION**, Crank Pulley.
14. Install the V-belts. Ref. to **INSTALLATION**, V-belt.
15. Install the throttle body to intake manifold.

NOTE: Use a new gasket.

Tightening torque:

8 N.m (0.8 kgf-m, 5.9 ft-lb)

16. Remove the ST (hanger) and install the engine hanger bracket.

Tightening torque:

19 N.m (1.9 kgf-m, 14.0 ft-lb)

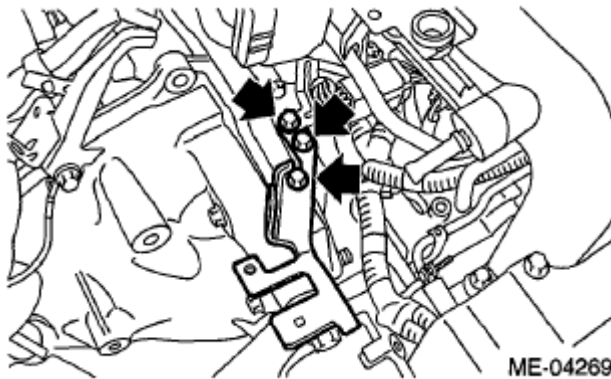


Fig. 128: Locating Engine Hanger Bracket Bolts
Courtesy of SUBARU OF AMERICA, INC.

17. Install the engine harness connector to the engine hanger bracket.

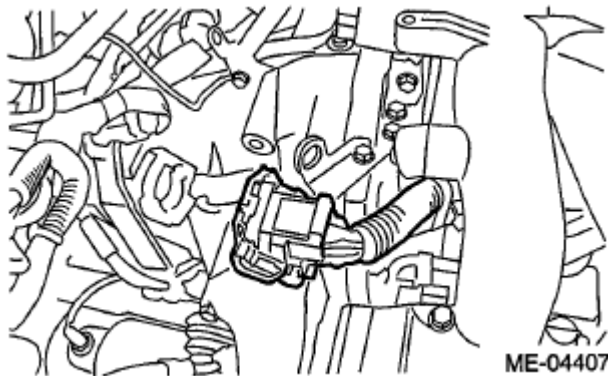


Fig. 129: Identifying Engine Harness Connector Of Engine Hanger Bracket
Courtesy of SUBARU OF AMERICA, INC.

18. Connect the connector to the throttle body.

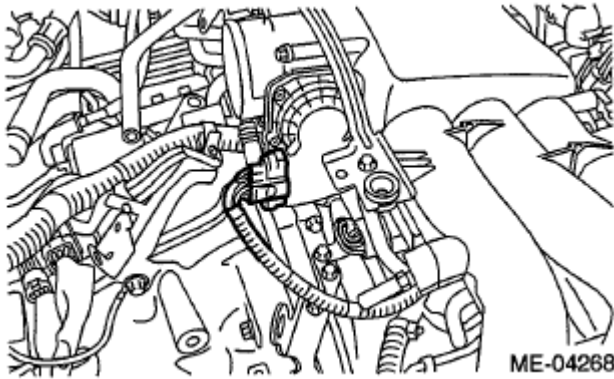


Fig. 130: Identifying Throttle Body Connector
Courtesy of SUBARU OF AMERICA, INC.

19. Connect the engine harness connector.

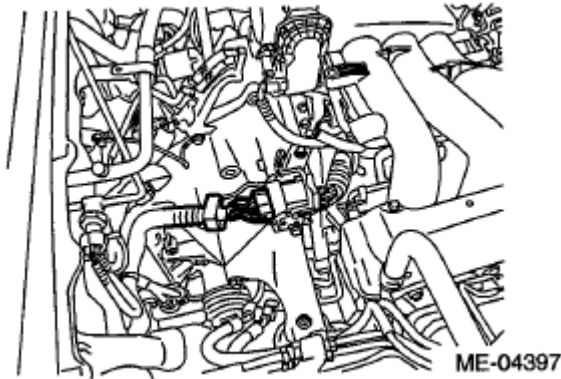
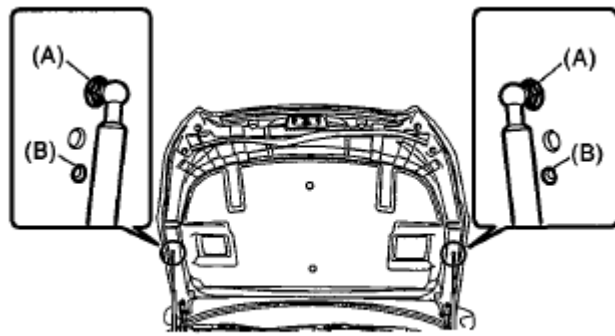


Fig. 131: Identifying Engine Harness Connector
Courtesy of SUBARU OF AMERICA, INC.

20. Install the V-belts. Ref. to **INSTALLATION**, V-belt.
21. Install the air intake boot assembly. Ref. to **INSTALLATION**, Air Intake Boot.
22. Install the air intake duct. Ref. to **INSTALLATION**, Air Intake Duct.
23. Install the front exhaust pipe. Ref. to **INSTALLATION**, Front Exhaust Pipe.
24. Fill engine coolant. Ref. to **FILLING OF ENGINE COOLANT**, REPLACEMENT, Engine Coolant.
25. Fill engine oil. Ref. to **REPLACEMENT**, Engine Oil.
26. Make sure there is no oil leaks in the chain cover mating surface.
27. Install the under cover. Ref. to **INSTALLATION**, Front Under Cover.
28. Install the collector cover.
29. Change the bolt mounting position from (B) to (A), and completely close the front hood.

Tightening torque:

20 N.m (2.0 kgf-m, 14.8 ft-lb)



ME-04396

Fig. 132: Identifying Front Hood Damper Bolt Mounting Position
Courtesy of SUBARU OF AMERICA, INC.

INSPECTION

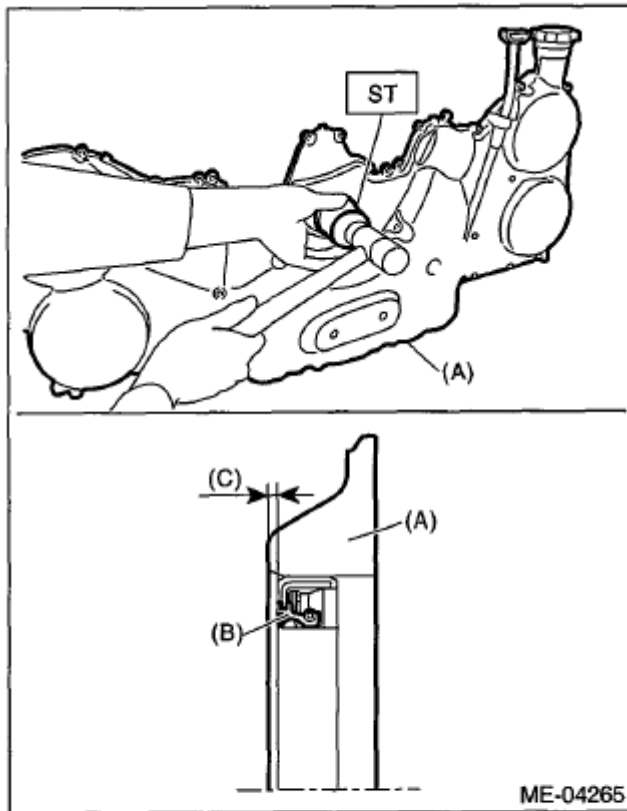
1. Check the chain cover surface for scratches or dents.
2. Check for oil leakage on the chain cover mating surface and installation part of crank pulley.

If there is an oil leak from the oil seal, perform replacement with a new oil seal.

ST 499585700 OIL SEAL GUIDE

Oil seal press-fit position:

Chain cover end face - Position -1 mm (-0.039 in) from the chain cover end face.

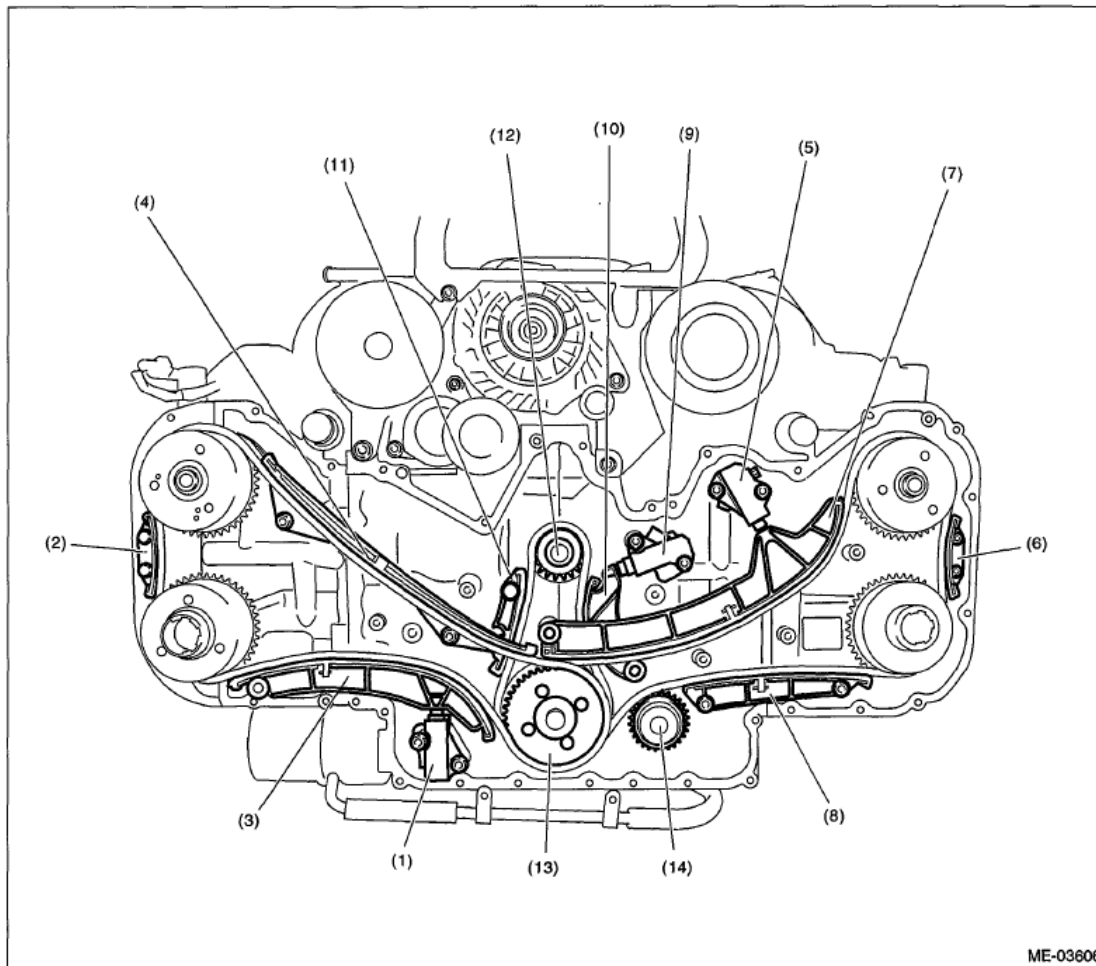


- (A) Chain cover
- (B) Oil seal
- (C) Oil seal press-fit position (chain cover edge – 1 mm (–0.039 in) position)

Fig. 133: Installing Oil Seal Using ST
Courtesy of SUBARU OF AMERICA, INC.

TIMING CHAIN ASSEMBLY

LOCATION



- | | | |
|------------------------------------|------------------------------------|--------------------------|
| (1) Chain tensioner (RH) | (6) Chain guide (Between cams, LH) | (11) Chain guide (Main) |
| (2) Chain guide (Between cams, RH) | (7) Chain tensioner lever (LH) | (12) Crank sprocket |
| (3) Chain tensioner lever (RH) | (8) Chain guide (LH) | (13) Idler sprocket |
| (4) Chain guide (RH) | (9) Chain tensioner (Main) | (14) Water pump sprocket |
| (5) Chain tensioner (LH) | (10) Chain tensioner lever (Main) | |

Fig. 134: Identifying Timing Chain Assembly Components
 Courtesy of SUBARU OF AMERICA, INC.

REMOVAL

NOTE:

- When replacing the single part, perform the work with the engine installed to body.
- To avoid mixing the timing chain component parts, separate each part after their removal.

1. Drain the engine oil. Ref. to **REPLACEMENT**, Engine Oil.
2. Remove the radiator. Ref. to **REMOVAL**, Radiator.
3. Remove the V-belts. Ref. to **REMOVAL**, V-belt.
4. Remove the crank pulley. Ref. to **REMOVAL**, Crank Pulley.

5. Remove the chain cover. Ref. to **REMOVAL**, Chain Cover.
6. Remove the chain tensioner (RH).

NOTE: When removing chain tensioner (RH), hold the plunger by hand so that it does not come flying out.

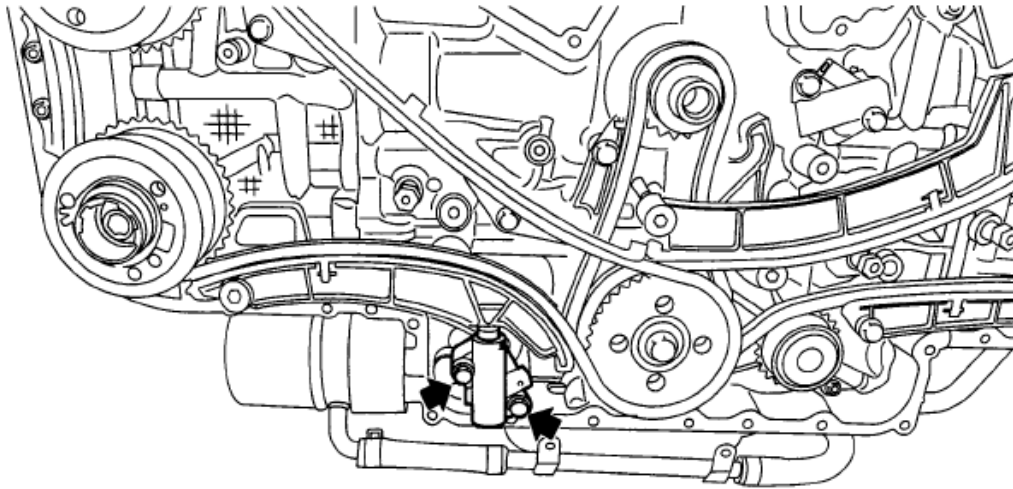


Fig. 135: Locating Chain Tensioner (RH) Bolts
Courtesy of SUBARU OF AMERICA, INC.

7. Remove the chain guide (RH: between cams).

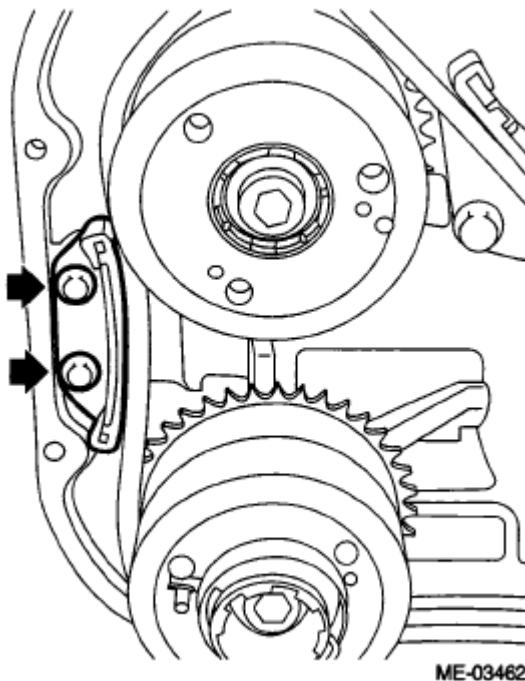
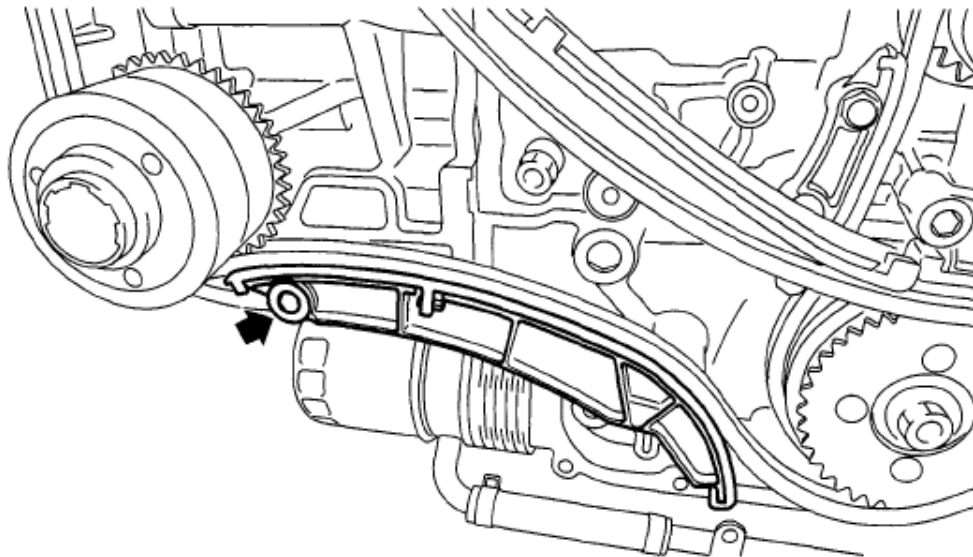


Fig. 136: Locating Chain Guide Bolts

Courtesy of SUBARU OF AMERICA, INC.

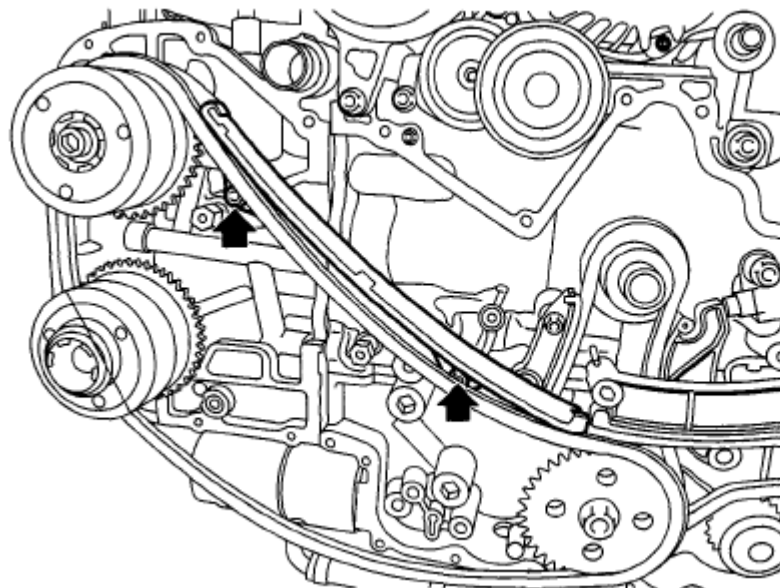
8. Remove the chain tensioner lever (RH).



ME-03463

Fig. 137: Locating Chain Tensioner Lever (RH)
Courtesy of SUBARU OF AMERICA, INC.

9. Remove the chain guide (RH).



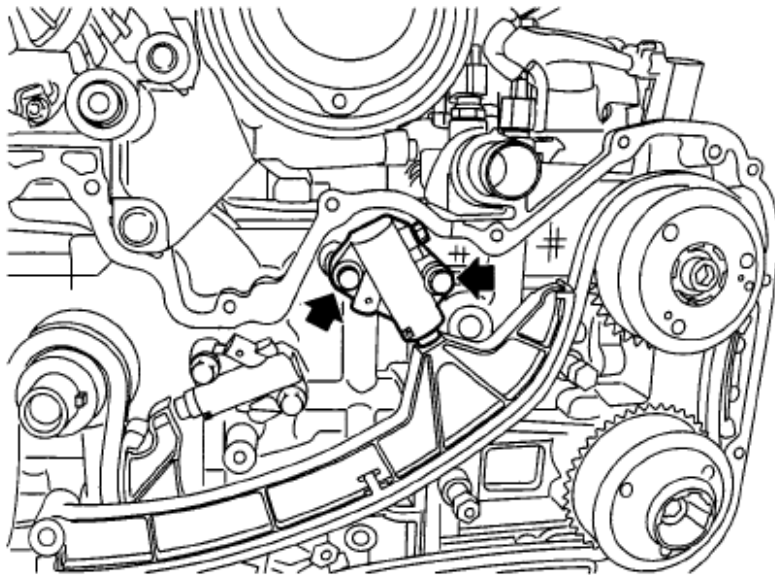
ME-03464

Fig. 138: Locating Chain Guide (RH)
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the timing chain (RH).

11. Remove the chain tensioner (LH).

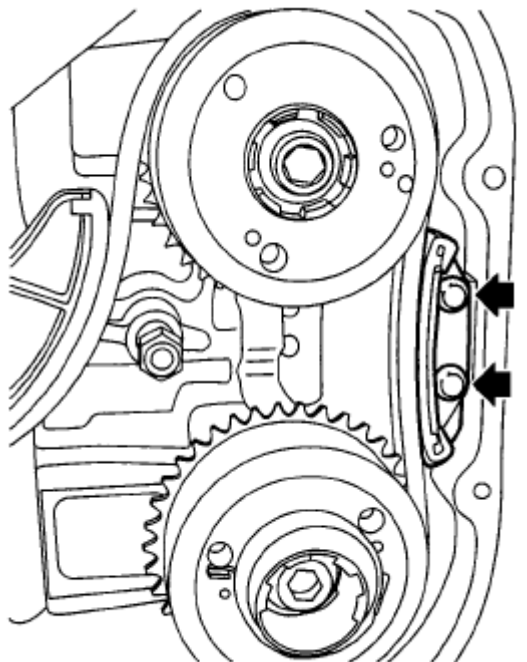
NOTE: When removing chain tensioner (LH), hold the plunger by hand so that it does not come flying out.



ME-03465

Fig. 139: Locating Chain Tensioner (LH) Bolts
Courtesy of SUBARU OF AMERICA, INC.

12. Remove the chain guide (LH: between cams).

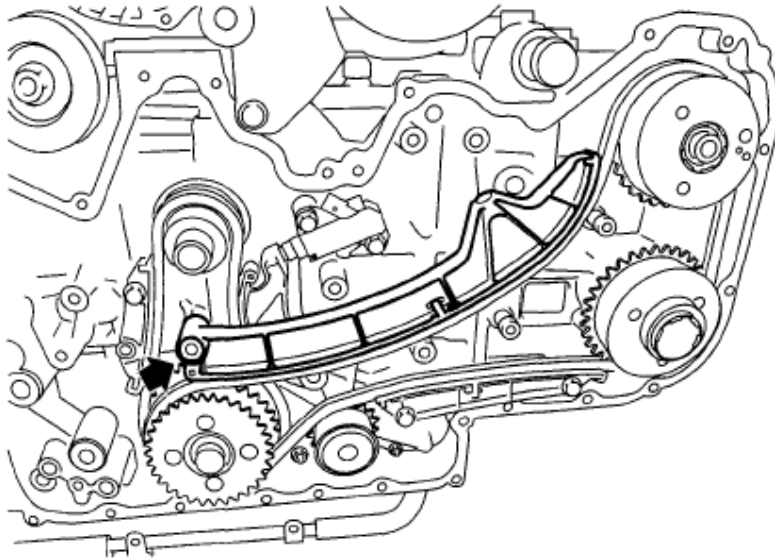


ME-03466

Fig. 140: Locating Chain Guide Bolts

Courtesy of SUBARU OF AMERICA, INC.

13. Remove the chain tensioner lever (LH).

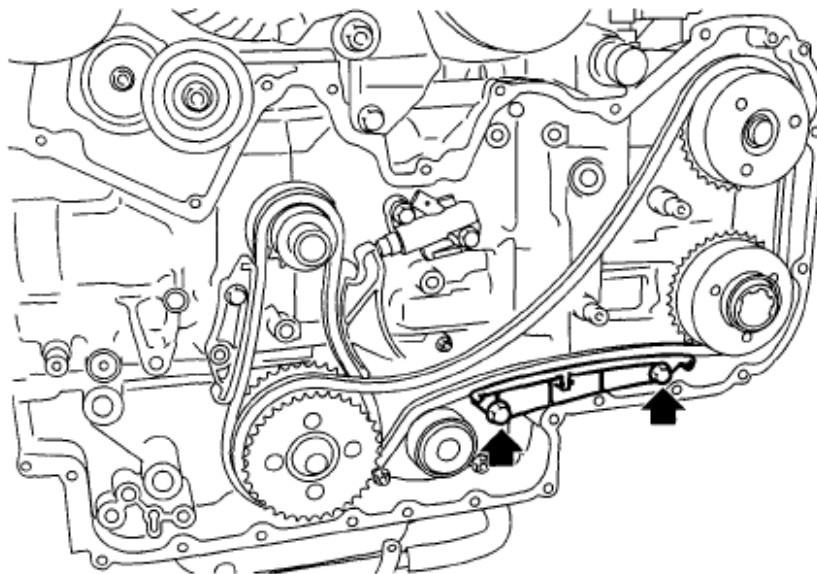


ME-03467

Fig. 141: Locating Chain Tensioner Lever (LH)

Courtesy of SUBARU OF AMERICA, INC.

14. Remove the chain guide (LH).



ME-03468

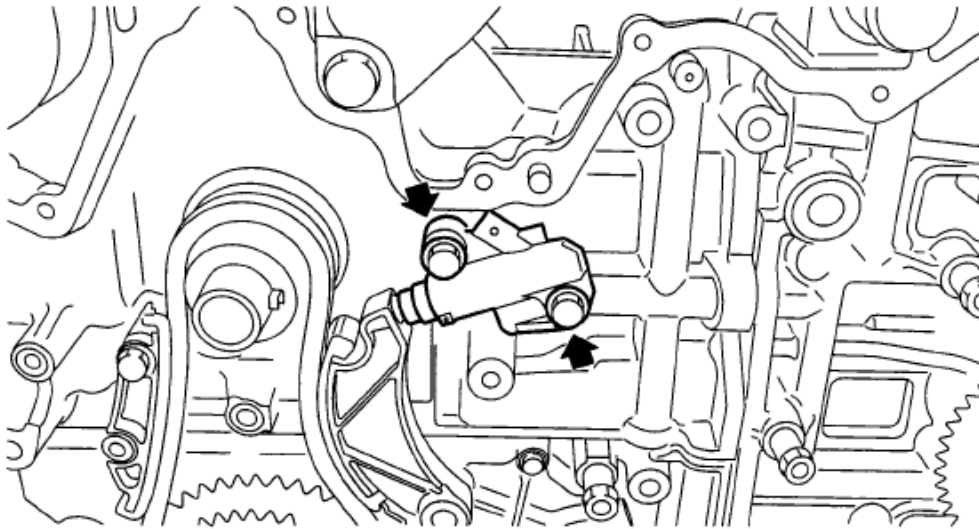
Fig. 142: Locating Chain Guide (LH) Bolts

Courtesy of SUBARU OF AMERICA, INC.

15. Remove the timing chain (LH).

16. Remove the chain tensioner (main).

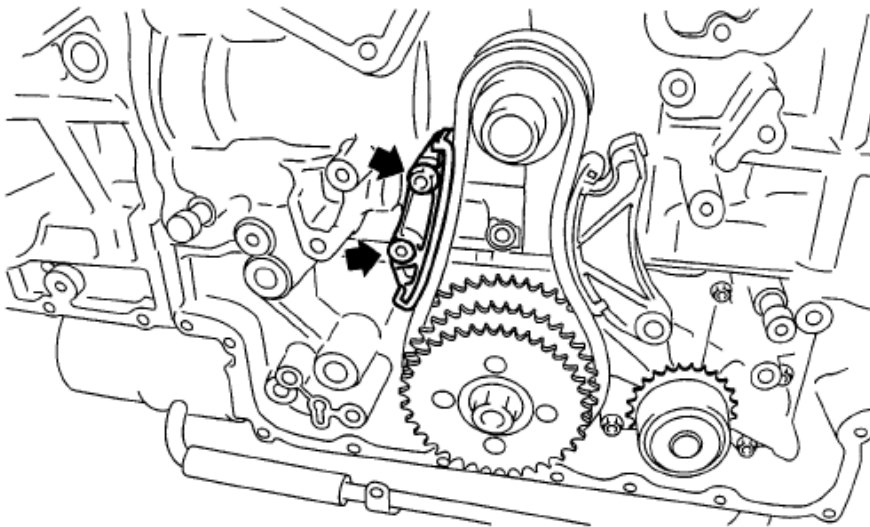
NOTE: When removing chain tensioner (main), hold the plunger by hand so that it does not come flying out.



ME-03469

Fig. 143: Locating Chain Tensioner (Main) Bolts
Courtesy of SUBARU OF AMERICA, INC.

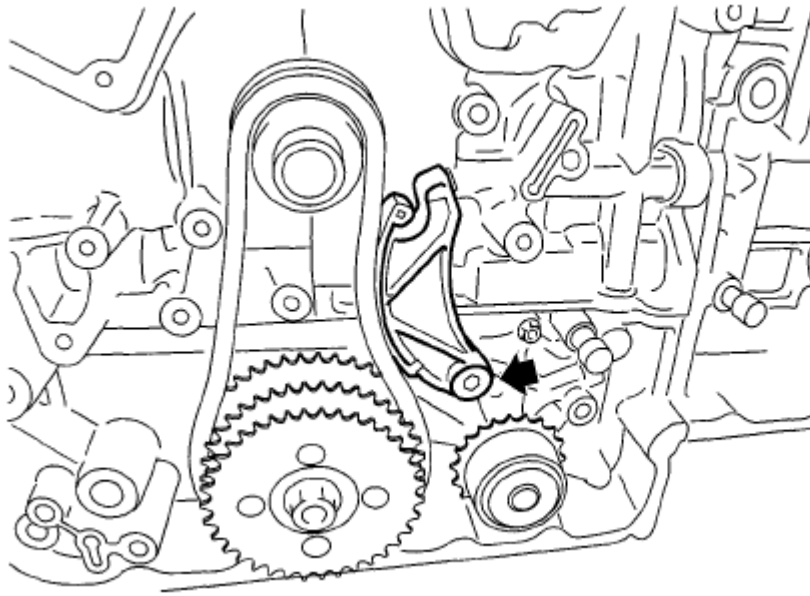
17. Remove the chain guide (main).



ME-03470

Fig. 144: Locating Chain Guide (Main)
Courtesy of SUBARU OF AMERICA, INC.

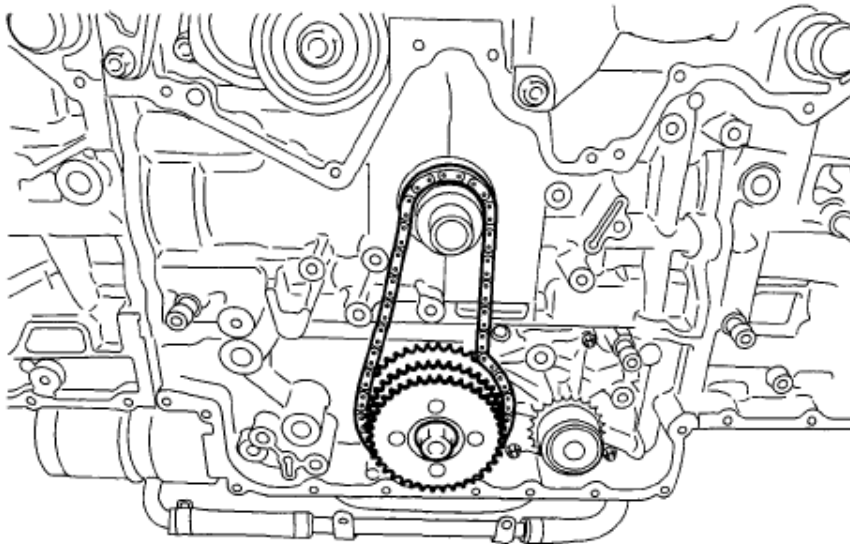
18. Remove the chain tensioner lever (main).



ME-03471

Fig. 145: Locating Chain Tensioner Lever (Main)
Courtesy of SUBARU OF AMERICA, INC.

19. Use the ST to lock the idler sprocket, and loosen the idler sprocket bolt.
20. Remove the idler sprocket bolts, and remove the idler sprocket and timing chain (main).



ME-03472

Fig. 146: Identifying Idler Sprocket Bolts, Idler Sprocket And Timing Chain (Main)
Courtesy of SUBARU OF AMERICA, INC.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET

INSTALLATION**NOTE:**

- Be careful that the foreign matter is not into or onto the assembled component during installation.
- Apply engine oil to all component parts of the timing chain.

1. Prepare to attach the chain tensioner.

1. Insert the screw, spring pin and plunger into the tensioner body.
2. As shown in the figure, turn the rubber mat counterclockwise while holding the chain tensioner from above by hand.

NOTE: Degrease the contact surface between the plunger head and rubber mat, so that they do not slip.

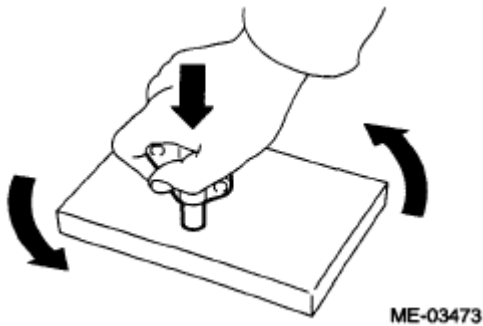
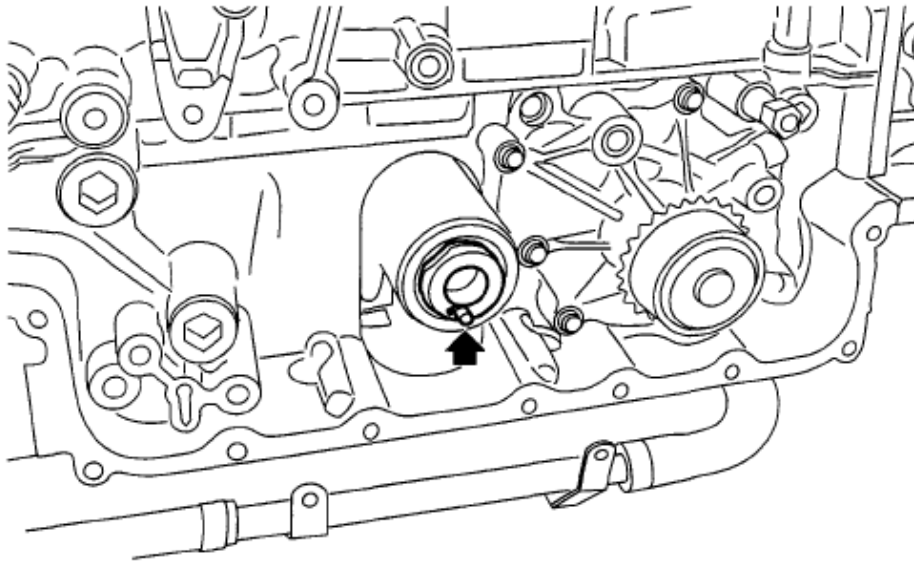


Fig. 147: Turning Rubber Mat
Courtesy of SUBARU OF AMERICA, INC.

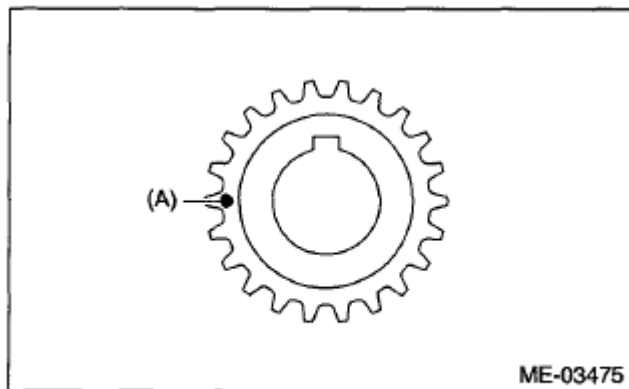
3. Insert the stopper pin into the hole on the chain tensioner body.
2. Align the position of oil pump shaft knock pin to six o'clock position as shown in the figure.



ME-03474

Fig. 148: Locating Oil Pump Shaft Knock Pin
Courtesy of SUBARU OF AMERICA, INC.

3. Using ST, align the "Top mark" on crank sprocket to nine o'clock position as shown in the figure.



ME-03475

(A) Top mark

Fig. 149: Identifying Top Mark On Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

4. Align the intake cam sprocket to twelve o'clock position as shown in the figure.

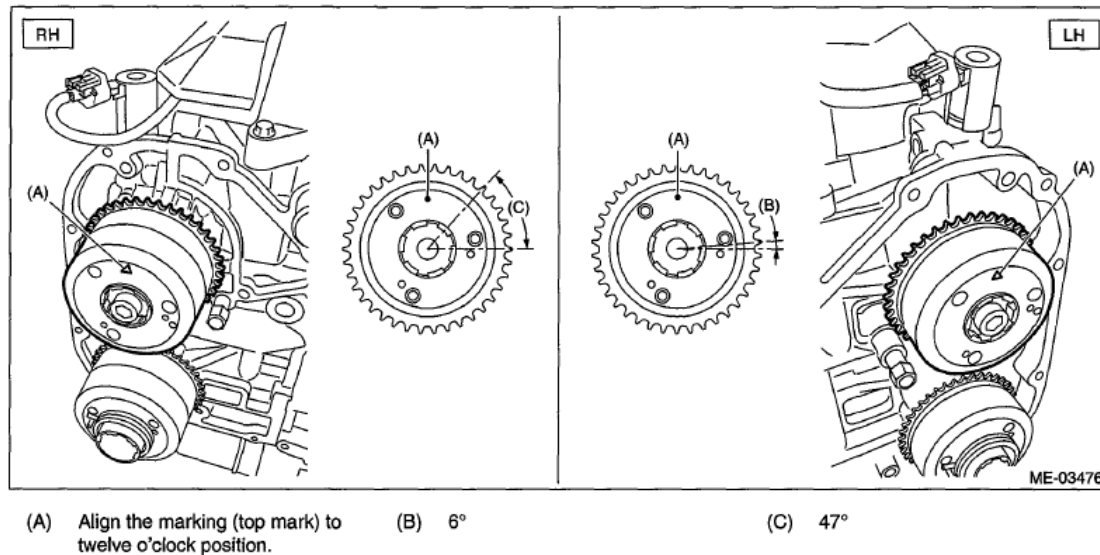


Fig. 150: Aligning Intake Cam Sprocket To Twelve O'Clock Position
Courtesy of SUBARU OF AMERICA, INC.

5. Align the exhaust cam sprocket to twelve o'clock position as shown in the figure.

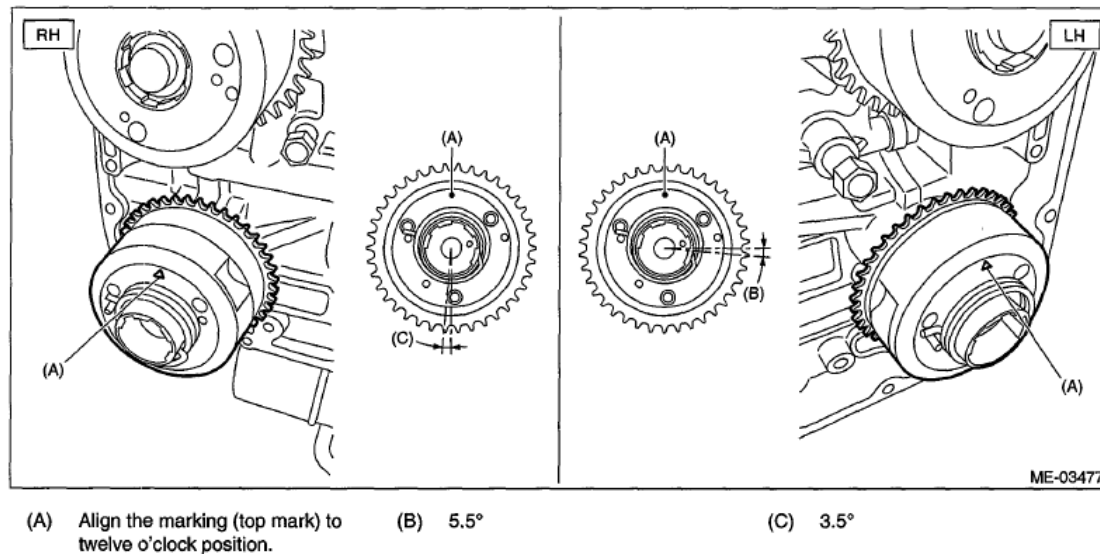
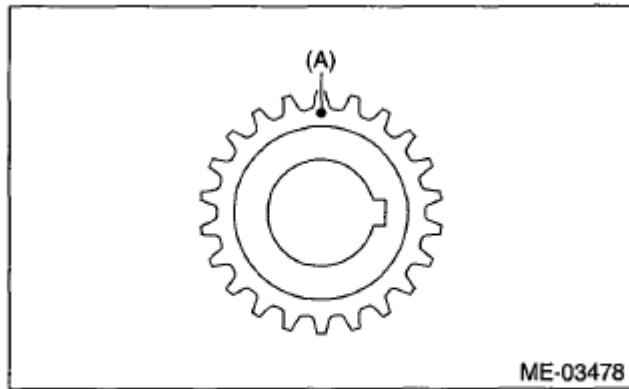


Fig. 151: Aligning Exhaust Cam Sprocket To Twelve O'Clock Position
Courtesy of SUBARU OF AMERICA, INC.

6. Using ST, align the "Top mark" on crank sprocket to twelve o'clock position as shown in the figure.

NOTE:

- The #1 piston is positioned at TDC.
- Do not rotate the crankshaft and cam sprocket before completing timing chain installation.
- At this time, crank sprocket key is at three o'clock position.



(A) Top mark

Fig. 152: Identifying Top Mark On Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

7. Install the chain guide (main).

Tightening torque:

16 N.m (1.6 kgf-m, 11.8 ft-lb)

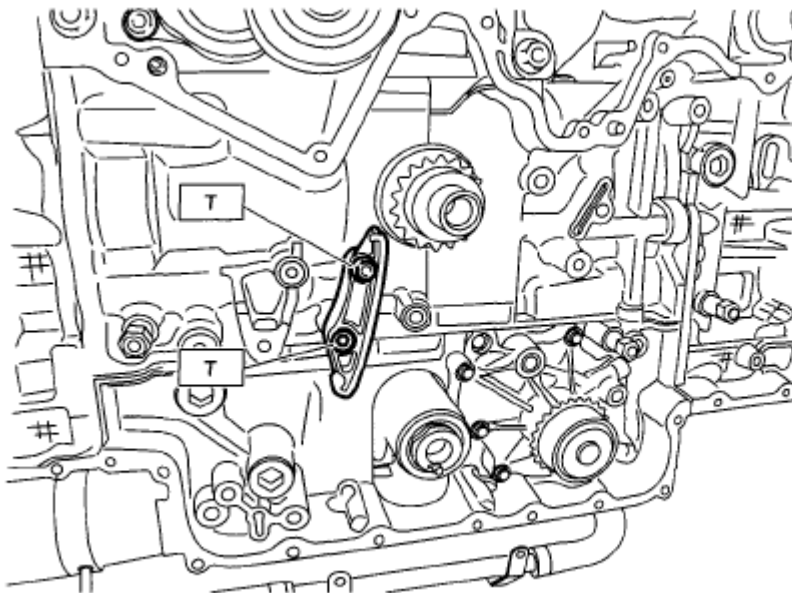


Fig. 153: Identifying Chain Guide Bolts (Main)
Courtesy of SUBARU OF AMERICA, INC.

8. Install the idler sprocket and timing chain (main).
 1. Match the timing chain mark (gold) to the timing mark position of the idler sprocket.
 2. Align the idler sprocket timing mark at six o'clock position, and install the idler sprocket and timing chain.

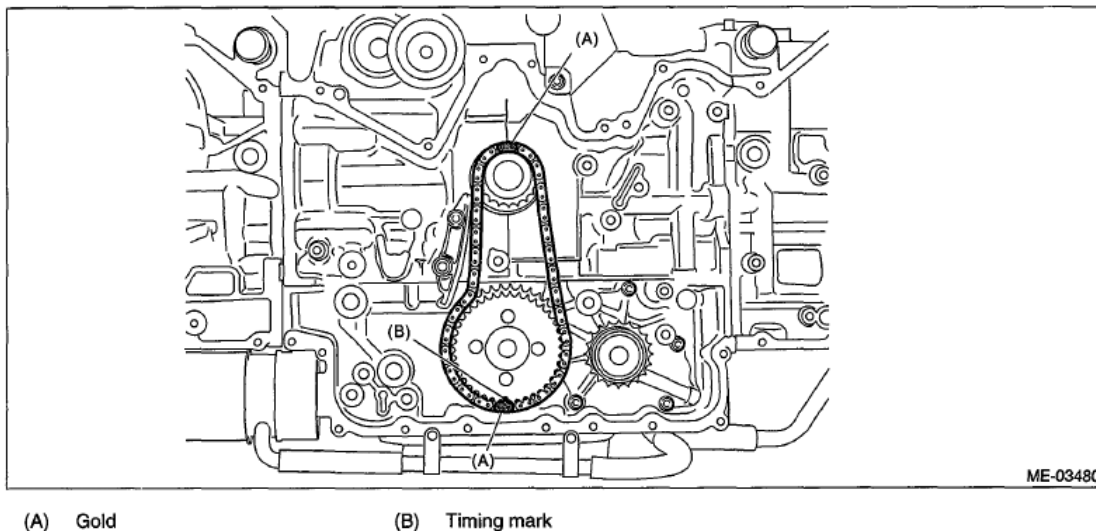
3. Make sure that the timing chain mark (gold) is located at twelve o'clock position on the crank sprocket.
4. Use the ST to lock the idler sprocket, and install the idler sprocket bolt.

ST1 18355AA000 PULLEY WRENCH

ST2 18334AA000 PULLEY WRENCH PIN SET

Tightening torque:

120 N.m (12.2 kgf-m, 88.5 ft-lb)



(A) Gold

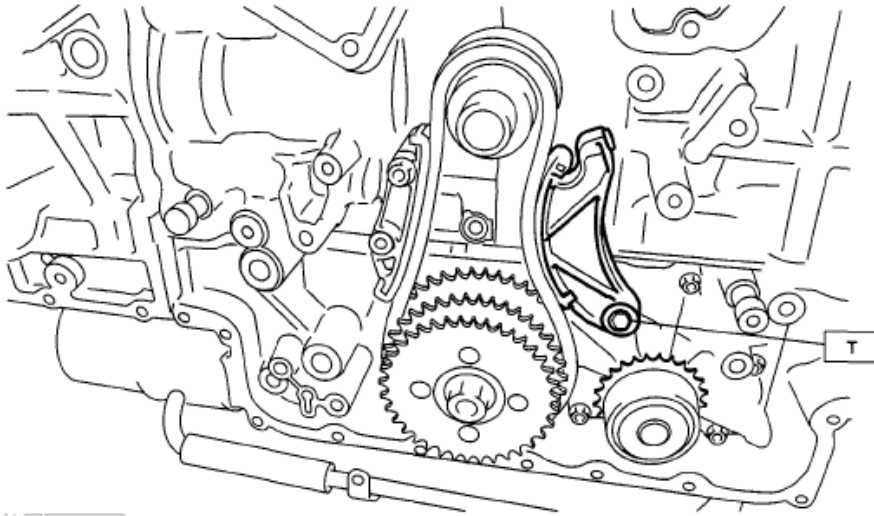
(B) Timing mark

Fig. 154: Identifying Timing Chain Mark (Gold)
Courtesy of SUBARU OF AMERICA, INC.

9. Install the chain tensioner lever (main).

Tightening torque:

16 N.m (1.6 kgf-m, 11.8 ft-lb)



ME-03481

Fig. 155: Identifying Chain Tensioner Lever (Main)

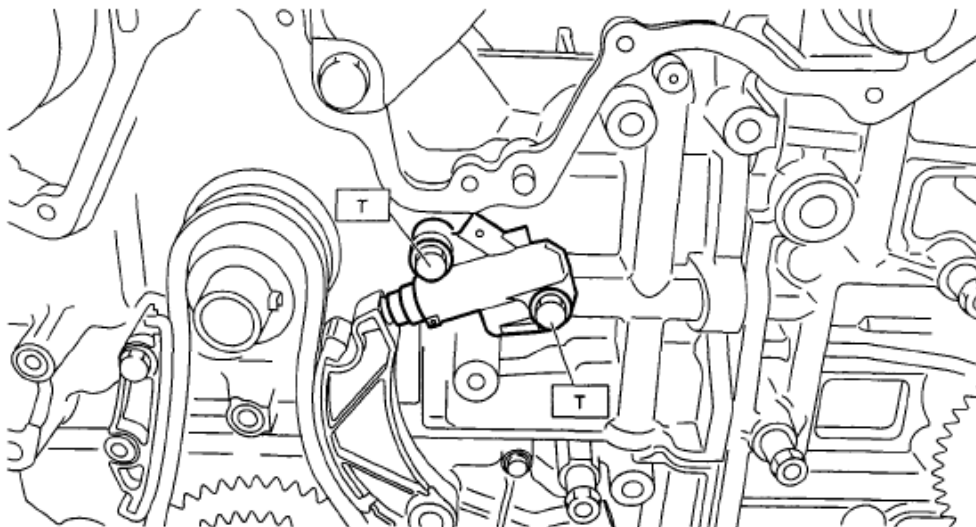
Courtesy of SUBARU OF AMERICA, INC.

10. Install the chain tensioner (main) and pull out the stopper pin.

NOTE: The timing chain (main) line will be complete.

Tightening torque:

16 N.m (1.6 kgf-m, 11.8 ft-lb)

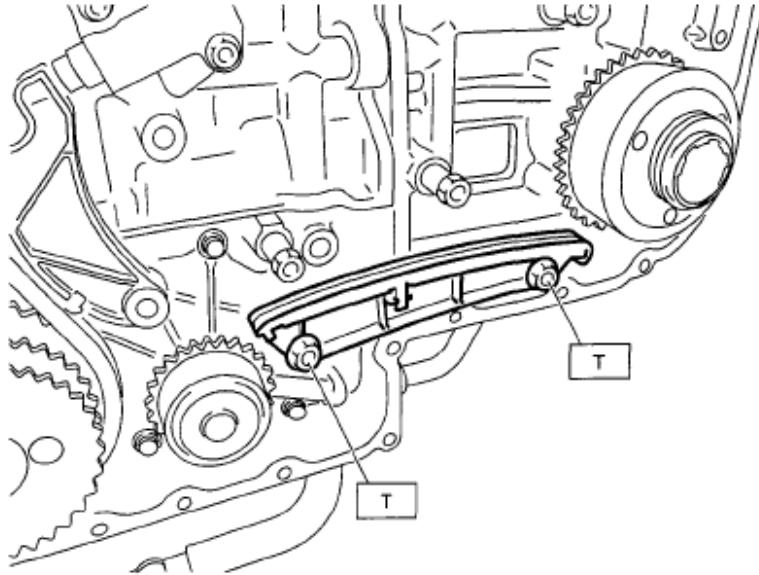


ME-03482

Fig. 156: Identifying Chain Tensioner Bolts (Main)

Courtesy of SUBARU OF AMERICA, INC.

11. Install the chain guide (LH).

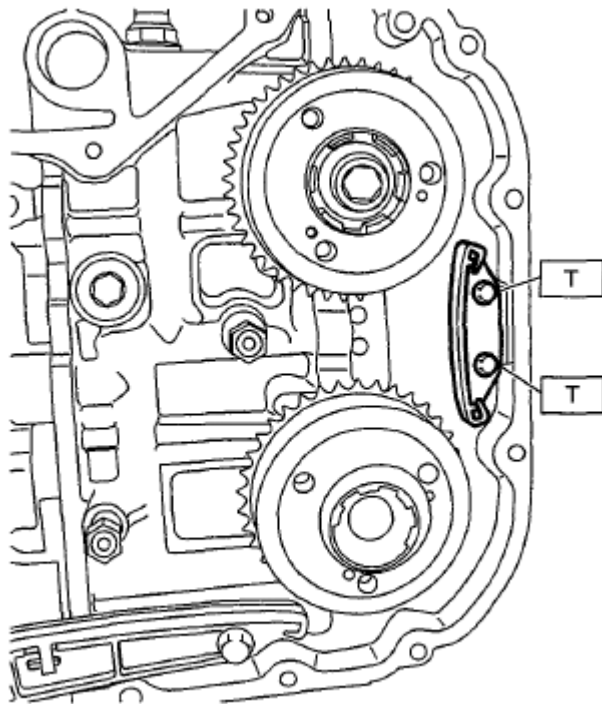
Tightening torque:***16 N.m (1.6 kgf-m, 11.8 ft-lb)***

ME-03483

Fig. 157: Identifying Chain Guide Bolts (LH)
Courtesy of SUBARU OF AMERICA, INC.

12. Install the chain guide (LH: between cams).

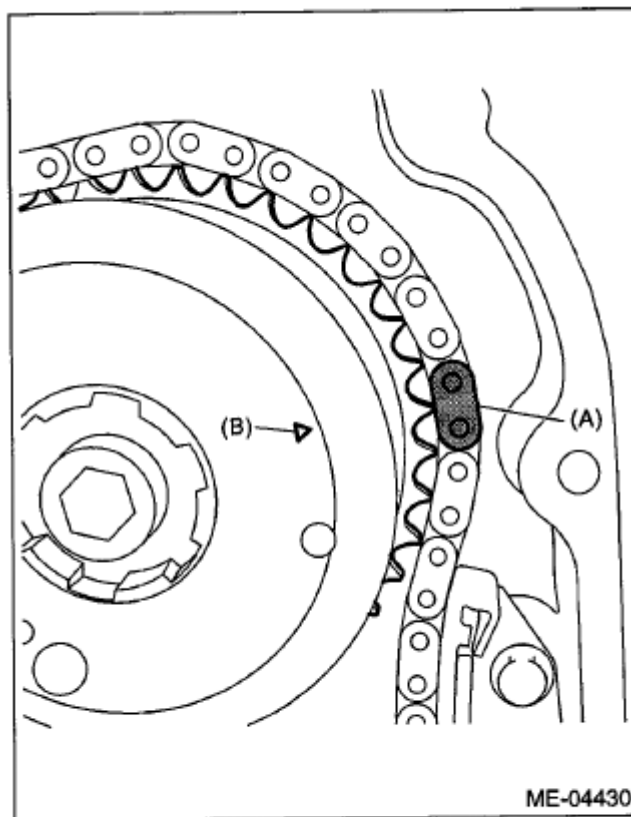
Tightening torque:***6.4 N.m (0.7 kgf-m, 4.7 ft-lb)***



ME-03607

Fig. 158: Identifying Chain Guide Bolts
Courtesy of SUBARU OF AMERICA, INC.

13. Install timing chain (LH).
 1. Match the timing mark of intake cam sprocket (LH) to the timing chain mark (blue).

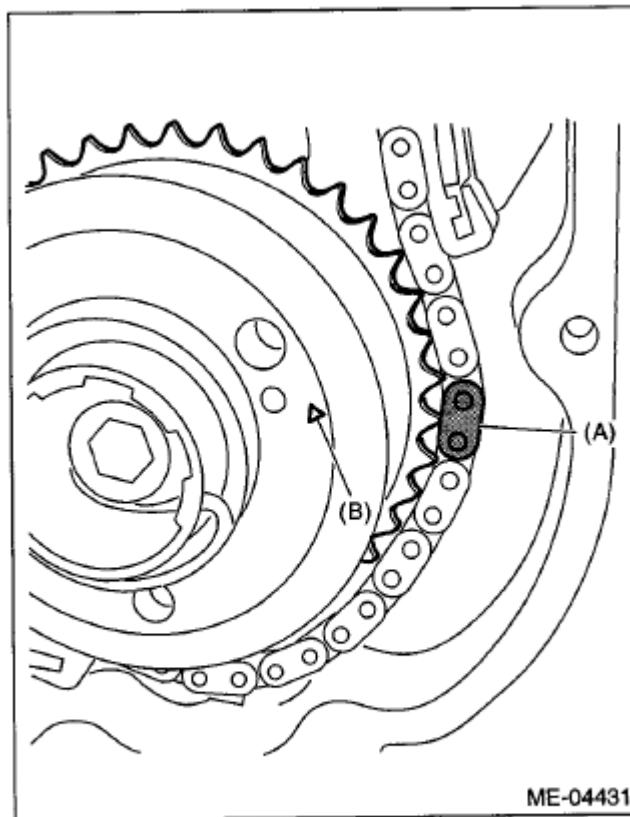


(A) Blue

(B) Timing mark

Fig. 159: Identifying Timing Chain Mark Of Intake Cam Sprocket (LH)
Courtesy of SUBARU OF AMERICA, INC.

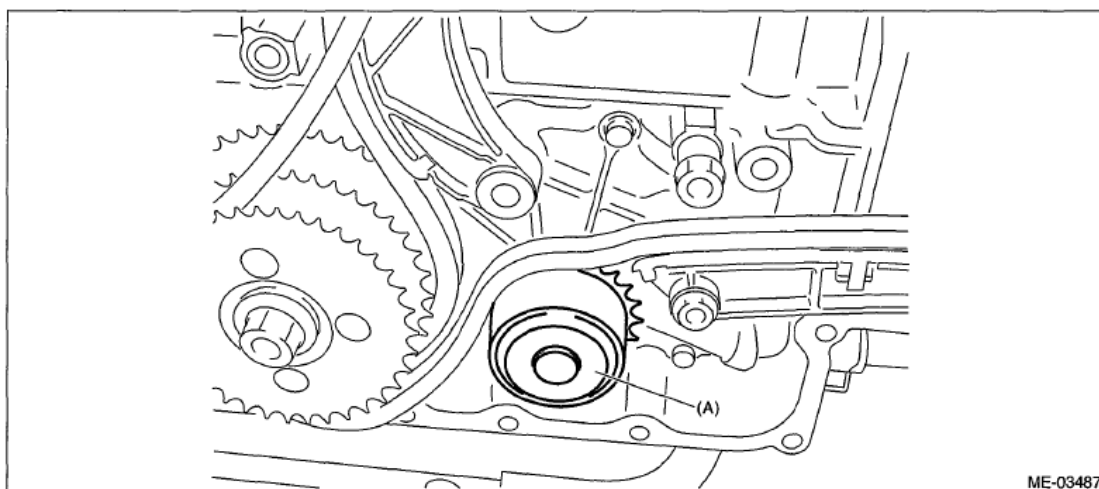
2. Match the timing mark of exhaust cam sprocket (LH) to the timing chain mark (blue).



- (A) Blue
- (B) Timing mark

Fig. 160: Identifying Timing Chain Mark Of Exhaust Cam Sprocket (LH)
 Courtesy of SUBARU OF AMERICA, INC.

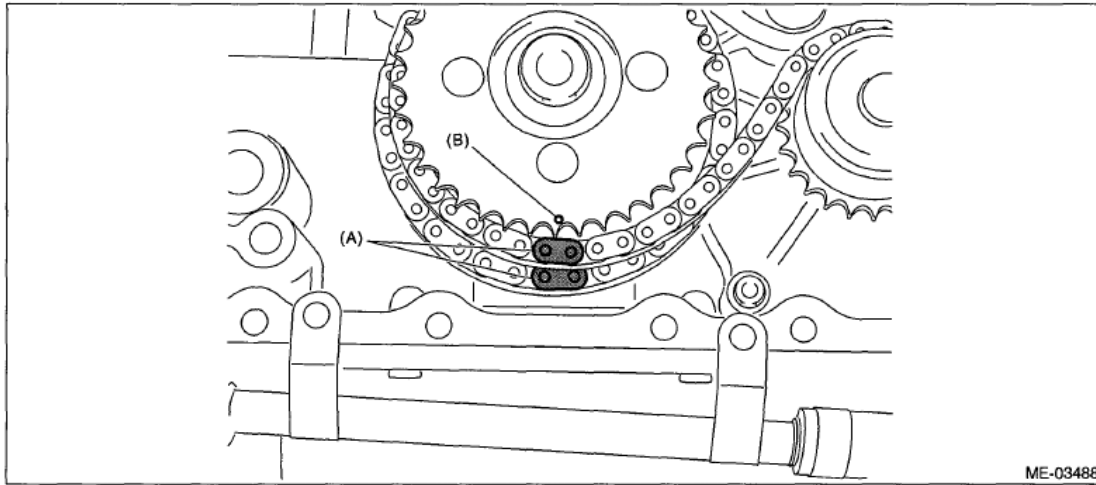
3. Install the timing chain to the water pump sprocket.



- (A) Water pump sprocket

Fig. 161: Identifying Water Pump Sprocket
Courtesy of SUBARU OF AMERICA, INC.

4. Match the timing mark of idler sprocket to the timing chain mark (gold).



(A) Gold

(B) Timing mark

Fig. 162: Identifying Timing Chain Mark (Gold)
Courtesy of SUBARU OF AMERICA, INC.

14. Install the chain tensioner lever (LH).

Tightening torque:

16 N.m (1.6 kgf-m, 11.8 ft-lb)

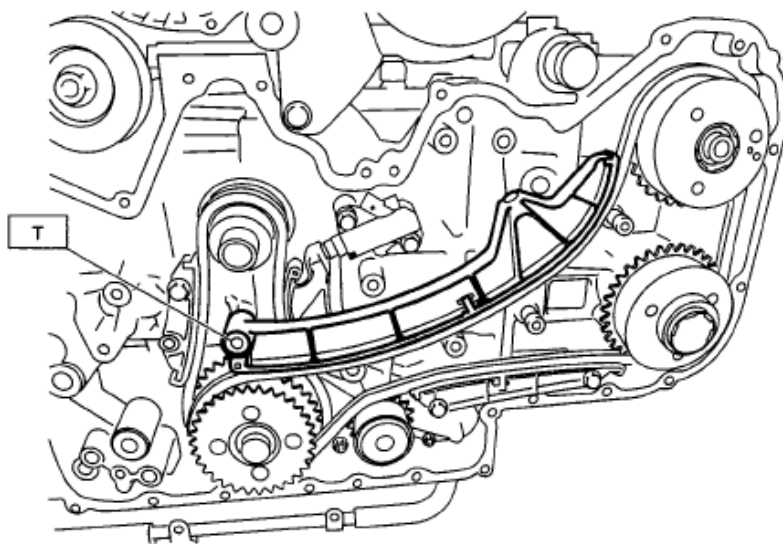


Fig. 163: Identifying Chain Tensioner Lever (LH)
Courtesy of SUBARU OF AMERICA, INC.

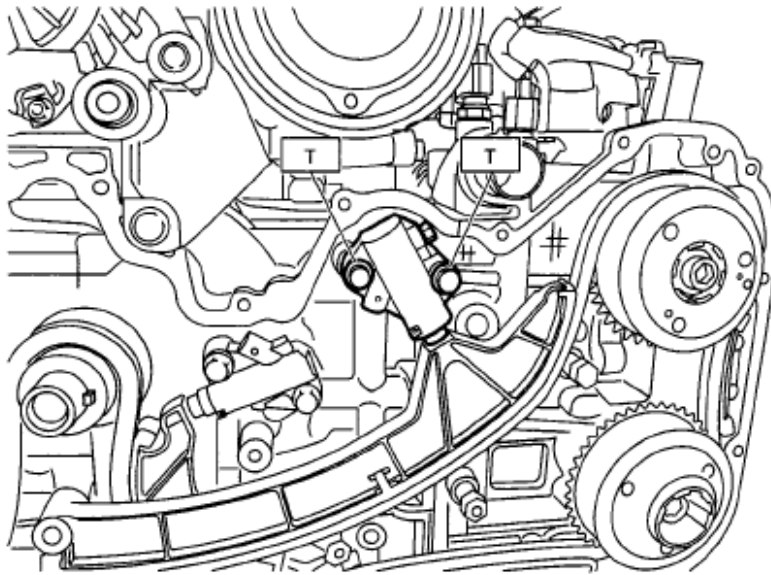
15. Install the chain tensioner (LH) and pull out the stopper pin.

NOTE:

- Make sure that there is a bolt attached on the side face of the chain tensioner housing.
- The timing chain (LH) line will be complete.

Tightening torque:

16 N.m (1.6 kgf-m, 11.8 ft-lb)



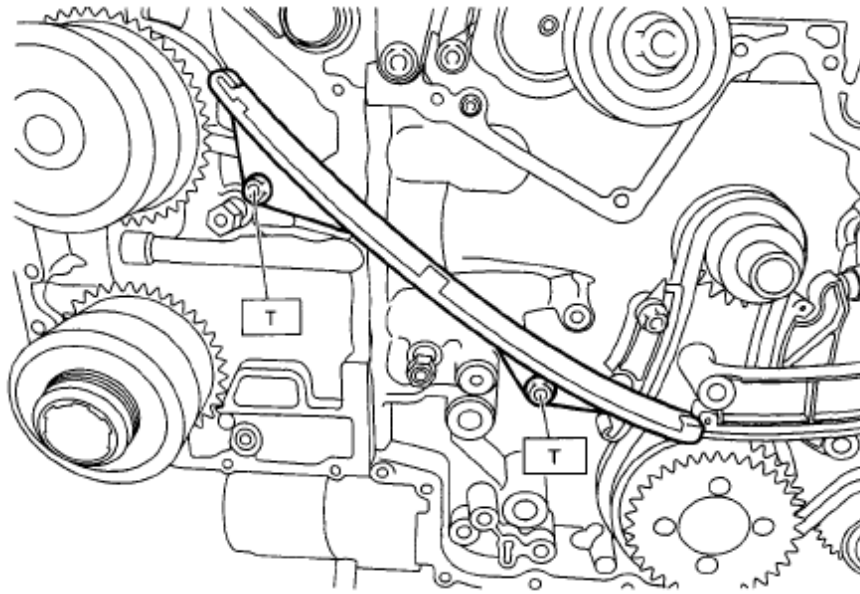
ME-03490

Fig. 164: Identifying Chain Tensioner Bolts (LH)
Courtesy of SUBARU OF AMERICA, INC.

16. Install the chain guide (RH).

Tightening torque:

16 N.m (1.6 kgf-m, 11.8 ft-lb)



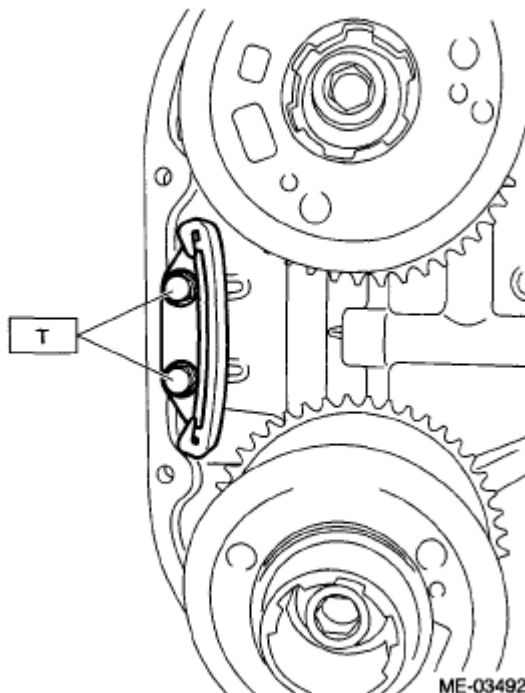
ME-03491

Fig. 165: Identifying Chain Guide Bolts (RH)
 Courtesy of SUBARU OF AMERICA, INC.

17. Install the chain guide (RH: between cams).

Tightening torque:

6.4 N.m (0.7 kgf-m, 4.7 ft-lb)



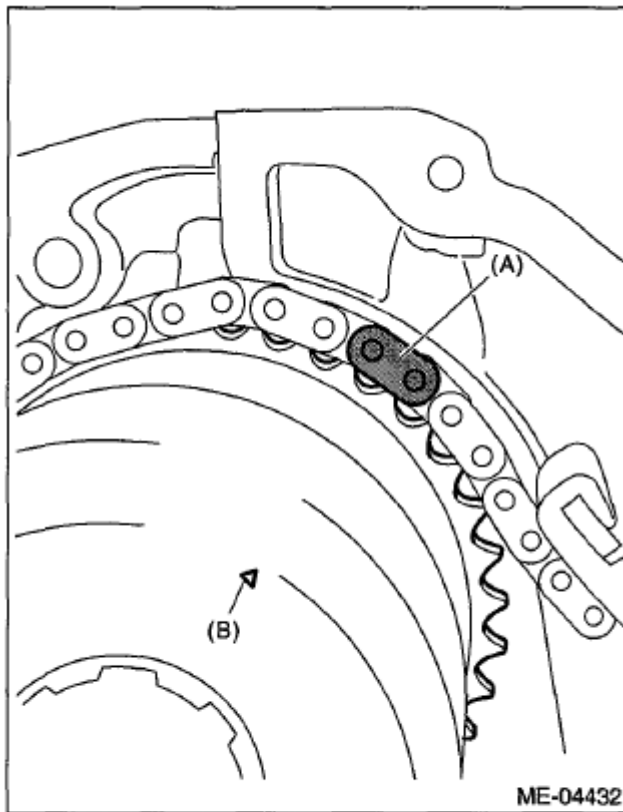
ME-03492

Fig. 166: Identifying Chain Guide Bolts (RH Between Cams)

Courtesy of SUBARU OF AMERICA, INC.

18. Install timing chain (RH).

1. Match the timing mark of intake cam sprocket (RH) to the timing chain mark (blue).

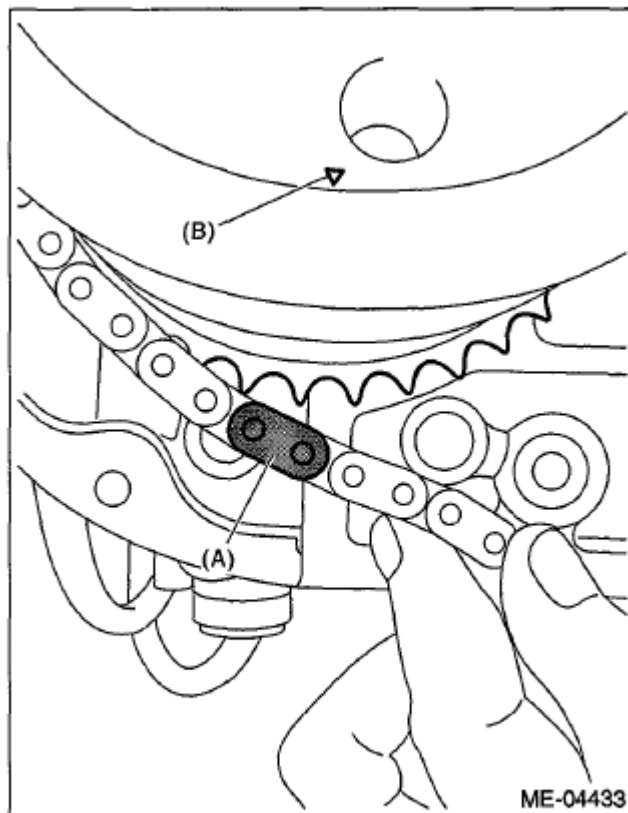


(A) Blue

(B) Timing mark

Fig. 167: Identifying Timing Chain Mark Of Intake Cam Sprocket (RH)
Courtesy of SUBARU OF AMERICA, INC.

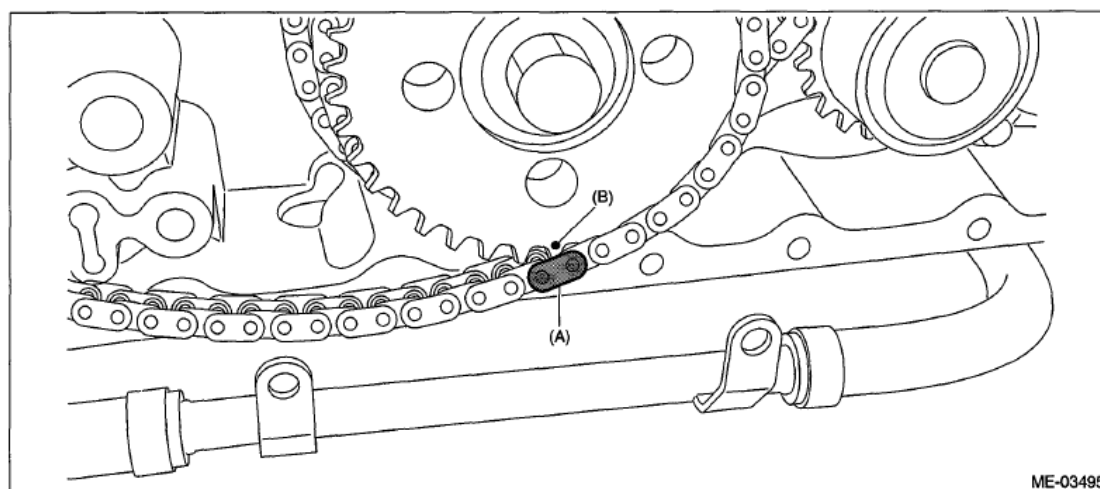
2. Match the timing mark of exhaust cam sprocket (RH) to the timing chain mark (blue).



- (A) Blue
- (B) Timing mark

Fig. 168: Identifying Timing Chain Mark Of Exhaust Cam Sprocket (RH)
 Courtesy of SUBARU OF AMERICA, INC.

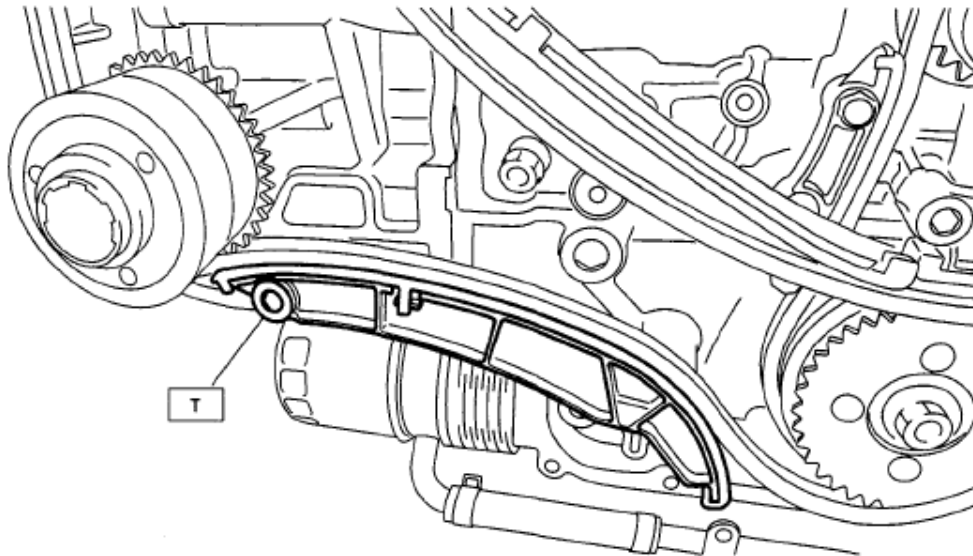
3. Match the timing mark of idler sprocket to the timing chain mark (gold).



- (A) Gold
- (B) Timing mark

Fig. 169: Identifying Timing Chain Mark (Gold)
Courtesy of SUBARU OF AMERICA, INC.

19. Install the chain tensioner lever (RH).

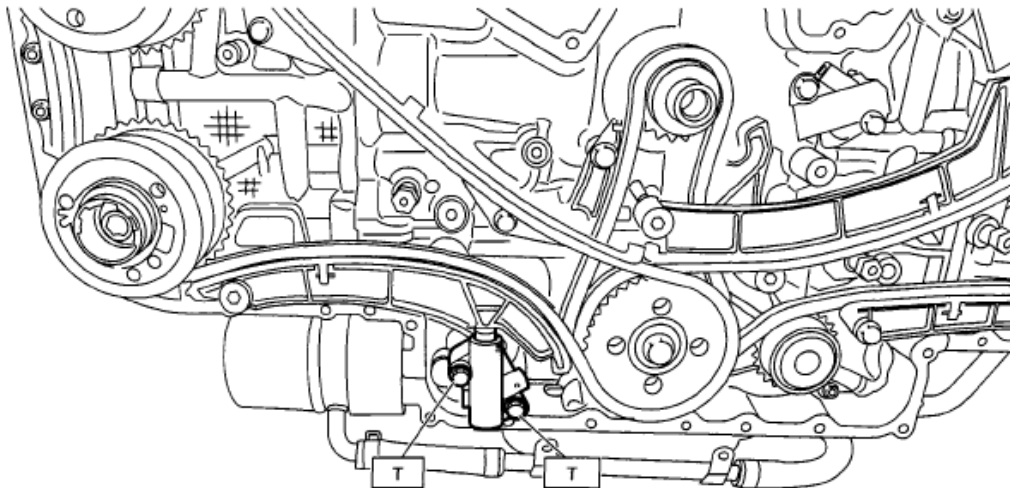


ME-03496

Fig. 170: Identifying Chain Tensioner Lever (RH)
Courtesy of SUBARU OF AMERICA, INC.

Tightening torque:

16 N.m (1.6 kgf-m, 11.8 ft-lb)



ME-03497

Fig. 171: Identifying Chain Tensioner Bolts (RH)
Courtesy of SUBARU OF AMERICA, INC.

20. Install the chain tensioner (RH) and pull out the stopper pin.

NOTE: The timing chain (RH) line will be complete.

Tightening torque:

16 N.m (1.6 kgf-m, 11.8 ft-lb)

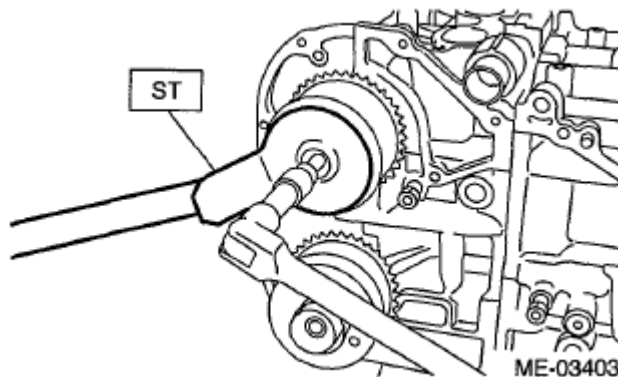


Fig. 172: Removing Cam Sprocket Bolt Using ST (IN Side)
Courtesy of SUBARU OF AMERICA, INC.

21. After installation, perform the following confirmations.

CAUTION: Always make sure to perform this confirmation.

1. Make sure that the timing mark of idler sprocket is aligned to three timing chain marks (gold).
 2. Make sure that the twelve o'clock position on the crank sprocket is aligned to the timing chain (main) mark (gold).
 3. Make sure that the LH side cam sprocket timing mark is aligned to the timing chain mark (blue).
 4. Make sure that the RH side cam sprocket timing mark is aligned to the timing chain mark (blue).
 5. Make sure that all bolts are tightened at the specified torque.
22. Using the ST, turn the crankshaft in the direction of engine rotation, and make sure that there are no abnormal conditions.

CAUTION: Always make sure to perform this confirmation.

23. Install the chain cover. Ref. to **INSTALLATION**, Chain Cover.
24. Install the crank pulley. Ref. to **INSTALLATION**, Crank Pulley.
25. Install the V-belts. Ref. to **INSTALLATION**, V-belt.
26. Fill engine oil. Ref. to **REPLACEMENT**, Engine Oil.
27. Make sure there is no oil leaks in the chain cover mating surface.
28. Install the radiator. Ref. to **INSTALLATION**, Radiator.

CAM SPROCKET

REMOVAL

NOTE: When replacing the single part, perform the work with the engine installed to body.

1. Remove the V-belts. Ref. to **REMOVAL**, V-belt.
2. Remove the crank pulley. Ref. to **REMOVAL**, Crank Pulley.
3. Remove the chain cover. Ref. to **REMOVAL**, Chain Cover.
4. Remove the timing chain assembly. Ref. to **REMOVAL**, Timing Chain Assembly.
5. Use the ST to lock the cam sprocket, and remove the cam sprocket bolt.

ST 499977500 CAM SPROCKET WRENCH

- IN side

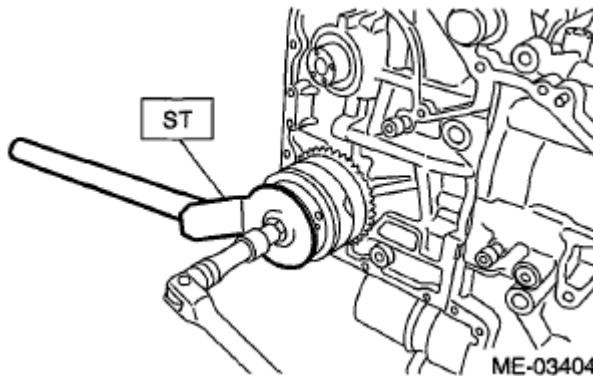


Fig. 173: Removing Cam Sprocket Bolt Using ST (EX Side)
Courtesy of SUBARU OF AMERICA, INC.

- Ex side

6. Remove the cam sprocket.

INSTALLATION

1. Remove the cam sprocket.
2. Use the ST to lock the cam sprocket, and install the cam sprocket bolt.

Tightening torque:

Tighten to 29.5 N.m (3.0 kgf-m, 21.8 ft-lb) of torque, and then tighten further by 45°.

ST 499977500 CAM SPROCKET WRENCH

- IN side

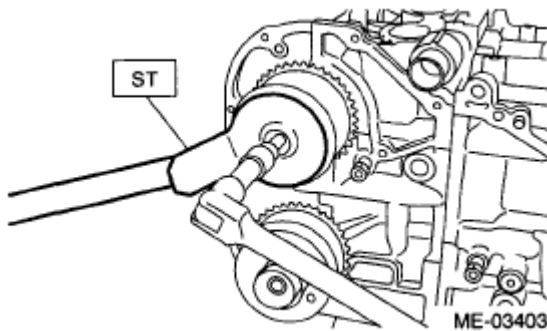


Fig. 174: Removing Cam Sprocket Bolt Using ST (IN Side)
 Courtesy of SUBARU OF AMERICA, INC.

- EX side

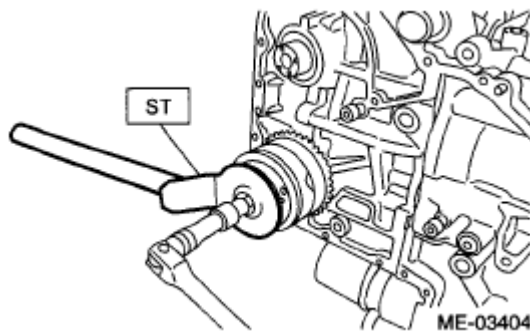


Fig. 175: Removing Cam Sprocket Bolt Using ST (EX Side)
 Courtesy of SUBARU OF AMERICA, INC.

3. Install the timing chain assembly. Ref. to **INSTALLATION**, Timing Chain Assembly.
4. Install the chain cover. Ref. to **INSTALLATION**, Chain Cover.
5. Install the crank pulley. Ref. to **INSTALLATION**, Crank Pulley.
6. Install the V-belts. Ref. to **INSTALLATION**, V-belt.

INSPECTION

1. Check the cam sprocket teeth for abnormal wear and scratches.
2. Make sure there is no free play between cam sprocket and key.

CRANK SPROCKET

REMOVAL

NOTE: When replacing the single part, perform the work with the engine installed to

body.

1. Remove the V-belts. Ref. to **REMOVAL**, V-belt.
2. Remove the crank pulley. Ref. to **REMOVAL**, Crank Pulley.
3. Remove the chain cover. Ref. to **REMOVAL**, Chain Cover.
4. Remove the timing chain assembly. Ref. to **REMOVAL**, Timing Chain Assembly.
5. Remove the crank sprocket (A).

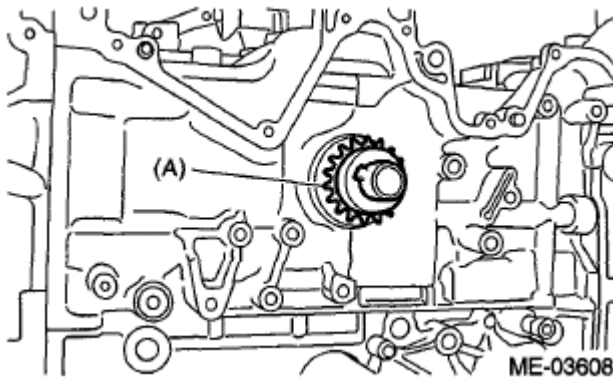


Fig. 176: Identifying Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

INSTALLATION

1. Install the crank sprocket (A).

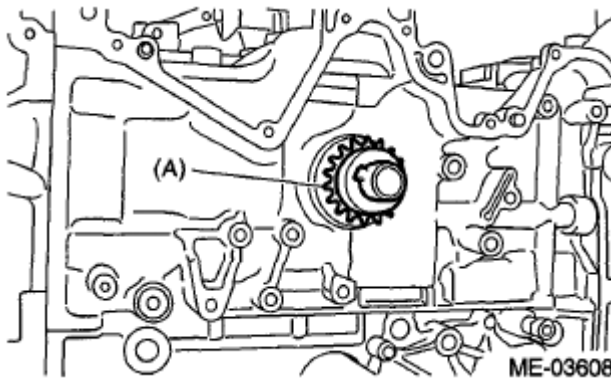


Fig. 177: Identifying Crank Sprocket
Courtesy of SUBARU OF AMERICA, INC.

2. Install the timing chain assembly. Ref. to **INSTALLATION**, Timing Chain Assembly.
3. Install the chain cover. Ref. to **INSTALLATION**, Chain Cover.
4. Install the crank pulley. Ref. to **INSTALLATION**, Crank Pulley.
5. Install the V-belts. Ref. to **INSTALLATION**, V-belt.

INSPECTION

1. Check the crank sprocket teeth for abnormal wear and scratches.
2. Make sure there is no free play between crank sprocket and key.

CAMSHAFT

REMOVAL

1. Remove the engine from vehicle. Ref. to **REMOVAL**, Engine Assembly.
2. Remove the crank pulley. Ref. to **REMOVAL**, Crank Pulley.
3. Remove the chain cover. Ref. to **REMOVAL**, Chain Cover.
4. Remove the timing chain assembly. Ref. to **REMOVAL**, Timing Chain Assembly.
5. Remove the cam sprocket. Ref. to **REMOVAL**, Cam Sprocket.
6. Remove the crank sprocket. Ref. to **REMOVAL**, Crank Sprocket.
7. Remove the exhaust oil flow control solenoid valve. Ref. to **REMOVAL**, Oil Flow Control Solenoid Valve.
8. Remove the camshaft position sensor. Ref. to **REMOVAL**, Camshaft Position Sensor.
9. Loosen the rocker cover bolts in the order indicated in the figure, and remove the rocker cover.
 - LH side

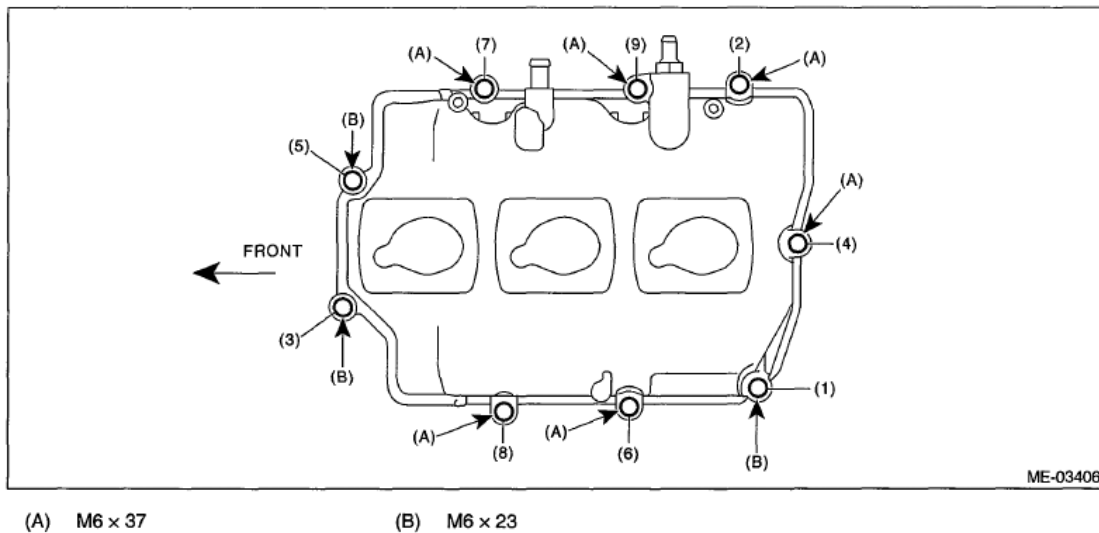


Fig. 178: Identifying Rocker Cover Bolts Loosening Order (LH Side)
 Courtesy of SUBARU OF AMERICA, INC.

- RH side

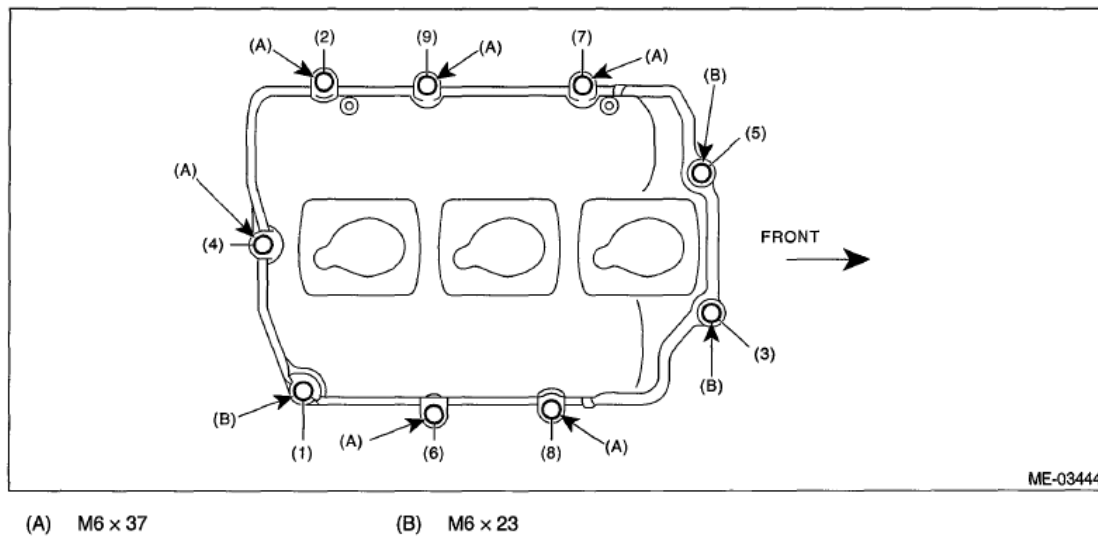


Fig. 179: Identifying Rocker Cover Bolts Loosening Order (RH Side)
Courtesy of SUBARU OF AMERICA, INC.

10. Loosen the camshaft cap bolts equally, a little at a time in numerical sequence, as shown in the figure.

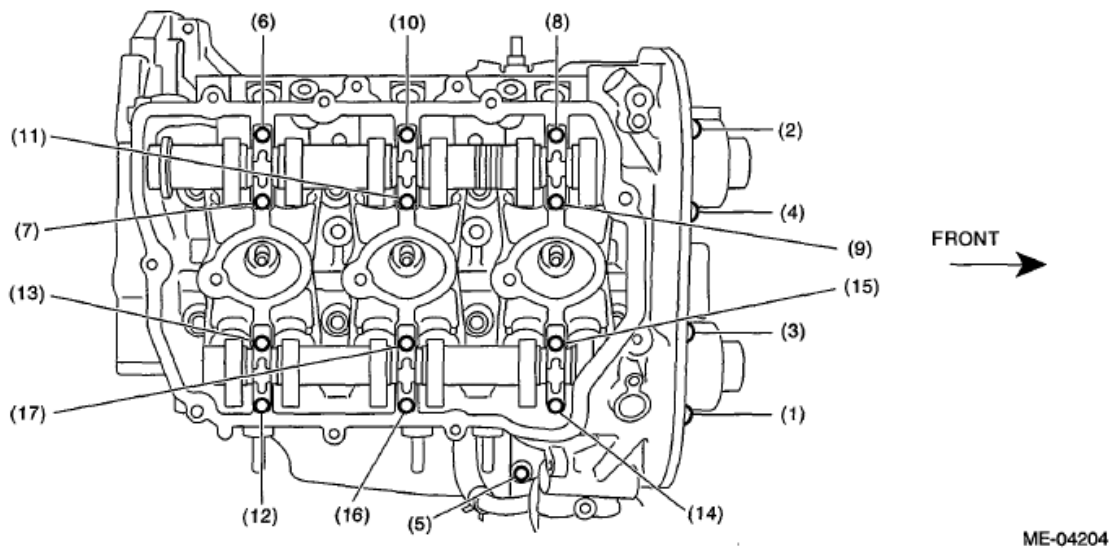


Fig. 180: Identifying Camshaft Cap Bolts Loosening Order
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the camshaft caps and camshaft (RH).

NOTE: Arrange camshaft caps in order so that they can be installed in their original positions.

12. Similarly, remove the camshaft (LH) and related parts.

INSTALLATION

1. Apply engine oil to camshaft journals, and install the camshaft.
2. Install the camshaft cap.
 1. Apply liquid gasket sparingly to back side of the front camshaft cap as shown in the figure.

NOTE:

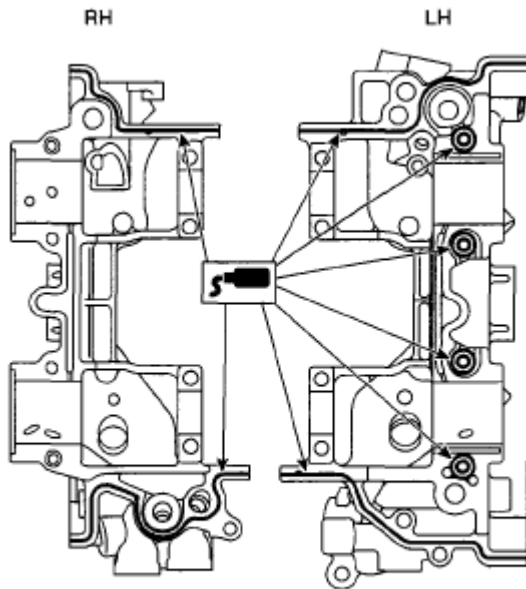
- Install within 5 min. after applying liquid gasket.
- Do not apply liquid gasket excessively. Applying excessively may cause excess gasket to come out and flow toward cam journal, resulting in engine seizure.

Liquid gasket:

THREE BOND 1217G (Part No. K0877Y0100) or equivalent

Liquid gasket applying diameter:

$2.0 \pm 0.5 \text{ mm}$ ($0.079 \pm 0.020 \text{ in}$)



ME-03408

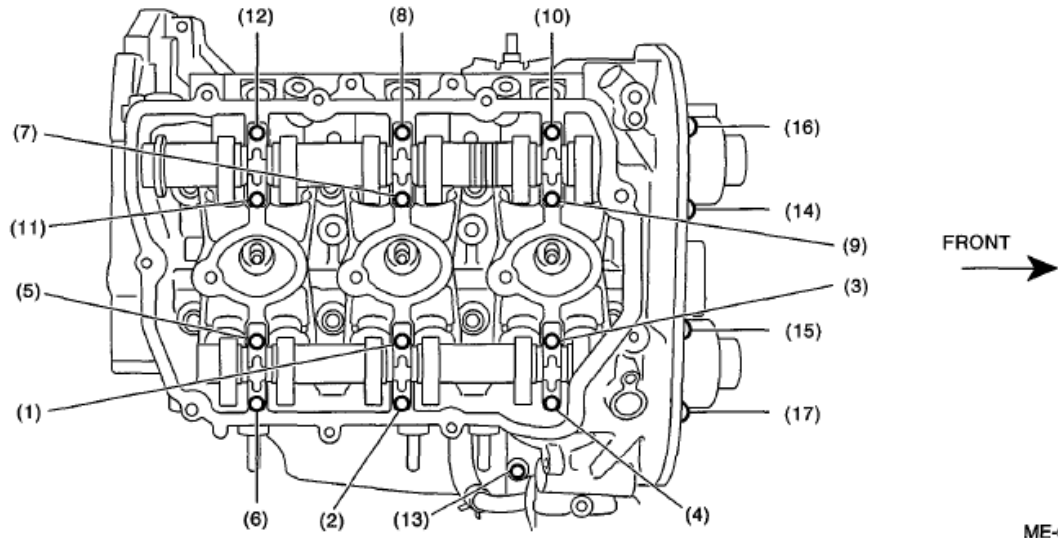
Fig. 181: Identifying Liquid Gasket Applying Area On Back Side Of Front Camshaft Cap
Courtesy of SUBARU OF AMERICA, INC.

2. Apply a thin coat of engine oil to the cap journal surface, and install the camshaft cap to the camshaft.
3. Gradually tighten the camshaft cap in at least two stages in the numerical order shown in the figure, then tighten to specified torque.

Tightening torque:

(1) - (12): 16 N.m (1.6 kgf-m, 11.8 ft-lb)

(13) - (17): 9.75 N.m (1.0 kgf-m, 7.2 ft-lb)



ME-04205

Fig. 182: Identifying Camshaft Cap Bolts Tightening Order
Courtesy of SUBARU OF AMERICA, INC.

4. After tightening the camshaft cap, ensure the camshaft rotates only slightly while holding it at base circle.
3. Install the rocker cover.
 1. Install the rocker cover gasket to the rocker cover.

NOTE: Use a new rocker cover gasket.

2. Apply liquid gasket sparingly to the mating surface of cylinder head and rocker cover as shown in the figure.

NOTE:

- Install within 5 min. after applying liquid gasket.
- Do not apply liquid gasket excessively. Applying excessively may cause excess gasket to come out and flow toward cam journal, resulting in engine seizure.

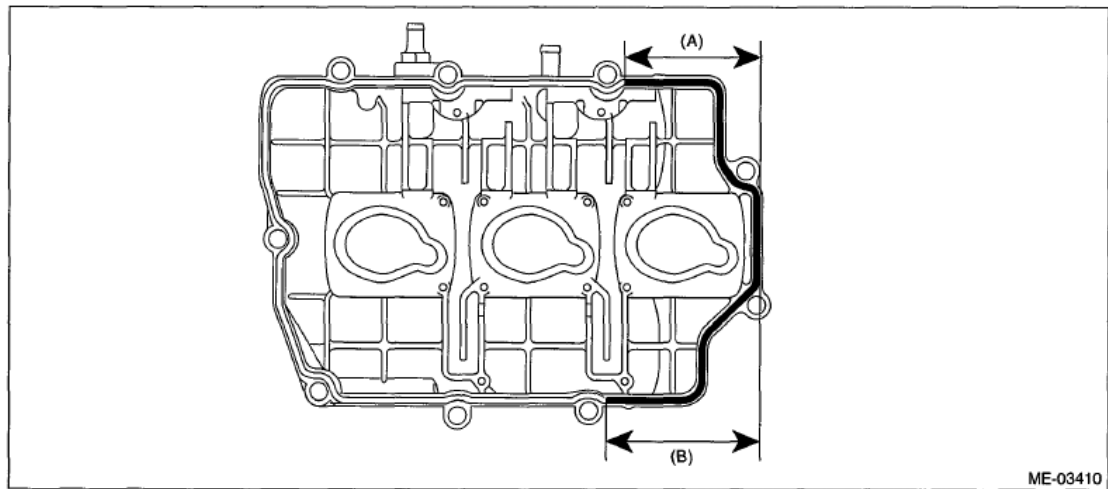
Liquid gasket:

THREE BOND 1217G (Part No. K0877Y0100) or equivalent

Liquid gasket applying diameter:

3.5±0.5 mm (0.138±0.020 in)

- LH side

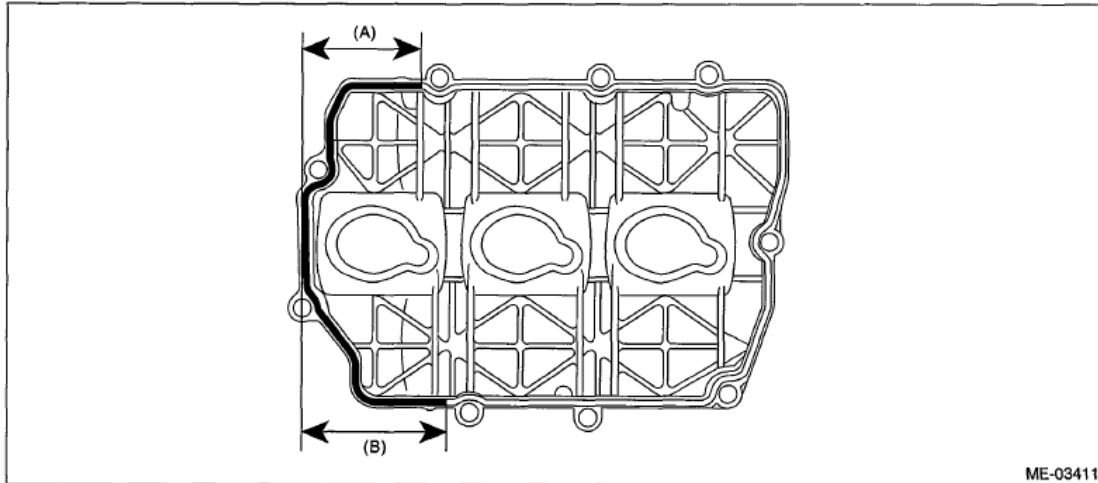


(A) 90 mm (3.543 in) or more (B) 105 mm (4.134 in) or more

ME-03410

Fig. 183: Identifying Liquid Gasket Applying Diameter (LH Side)
Courtesy of SUBARU OF AMERICA, INC.

- RH side



(A) 80 mm (3.150 in) or more (B) 100 mm (3.937 in) or more

ME-03411

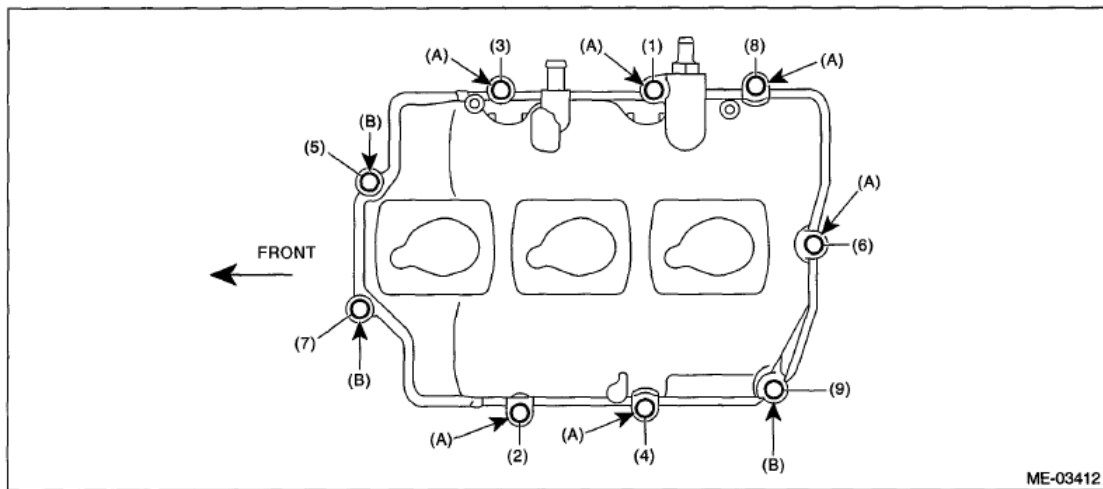
Fig. 184: Identifying Liquid Gasket Applying Diameter (RH Side)
Courtesy of SUBARU OF AMERICA, INC.

3. Tighten the rocker cover bolts in the numerical order as shown in the figure.

Tightening torque:

6.4 N.m (0.7 kgf-m, 4.7 ft-lb)

- LH side

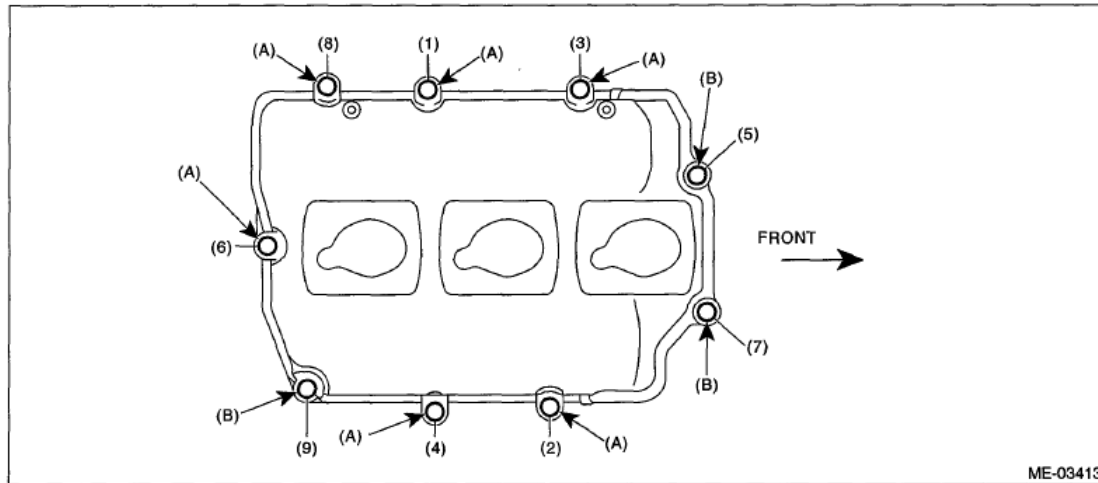


(A) M6 x 37

(B) M6 x 23

Fig. 185: Identifying Rocker Cover Bolts Tightening Order (LH Side)
Courtesy of SUBARU OF AMERICA, INC.

- RH side



(A) M6 x 37

(B) M6 x 23

Fig. 186: Identifying Rocker Cover Bolts Tightening Order (RH Side)
Courtesy of SUBARU OF AMERICA, INC.

4. Install the crank sprocket. Ref. to **INSTALLATION**, Crank Sprocket.
5. Install the cam sprocket. Ref. to **INSTALLATION**, Cam Sprocket.
6. Install the timing chain assembly. Ref. to **INSTALLATION**, Timing Chain Assembly.
7. Install the chain cover. Ref. to **INSTALLATION**, Chain Cover.
8. Install the crank pulley. Ref. to **INSTALLATION**, Crank Pulley.

9. Install the engine to the vehicle. Ref. to **INSTALLATION**, Engine Assembly.

INSPECTION

1. Measure and inspect the degree of bending. Repair or replace if necessary.

Camshaft bend limit:

0.020 mm (0.00079 in)

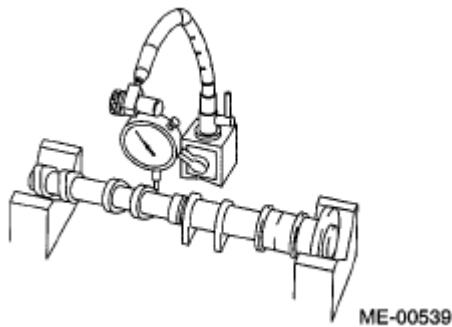


Fig. 187: Checking Camshaft Bend

Courtesy of SUBARU OF AMERICA, INC.

2. Check the journal for damage and wear. Replace if faulty.
3. Check the cutout portion used for camshaft sensor for damage. Replace if faulty.
4. Check the cam face condition; remove the minor faults by grinding with oil stone. Replace if there is uneven wear or others.
5. Measure the cam lobe height "H" and cam base circle diameter "A". If it exceeds the standard or offset wear occurs, replace it.

Cam lobe height H:

Standard

Intake

45.90 - 46.00 mm (1.8071 - 1.8110 in)

Exhaust

44.65 - 44.75 mm (1.7579 - 1.7618 in)

Cam base circle diameter A:

Standard

Intake

36.00 mm (1.4173 in)

Exhaust

36.00 mm (1.4137 in)

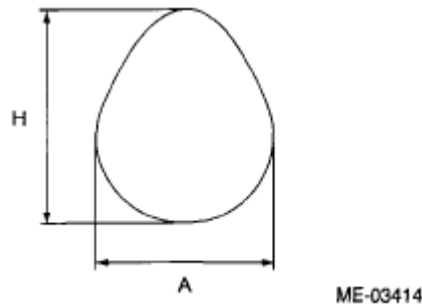


Fig. 188: Identifying Cam Lobe Height
Courtesy of SUBARU OF AMERICA, INC.

6. Measure the outside diameter of camshaft journal. If the journal diameter is not within specification, check the oil clearance.

CAMSHAFT JOURNAL SPECIFICATION CHART

	Camshaft journal	
	Front	Except for front
Standard mm (in)	37.946 - 37.963 (1.4939-1.4946)	25.946 - 25.963 (1.0215-1.0222)

7. Measure the oil clearance of camshaft journal.
 1. Clean the camshaft cap and cylinder head camshaft journal.
 2. Place the camshaft on cylinder head. (Without installing the valve lifter)
 3. Place a plastigauge across each camshaft journals.
 4. Gradually tighten the camshaft cap in at least two stages in the numerical order shown in the figure, then tighten to specified torque. Do not turn the camshaft.
 5. Remove the camshaft cap.
 6. Measure the widest point of the plastigauge on each journal. If oil clearance exceeds the standard, replace the camshaft. If necessary, replace the camshaft caps and cylinder head as a set.

Camshaft oil clearance:

Standard

0.037 - 0.072 mm (0.0015 - 0.0028 in)

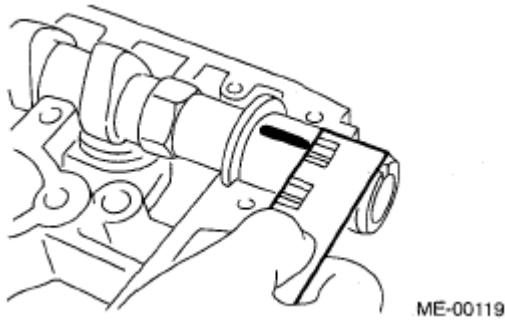


Fig. 189: Measuring Oil Clearance Of Camshaft Journal
Courtesy of SUBARU OF AMERICA, INC.

7. Completely remove the plastigauge.
8. Measure the thrust clearance of camshaft with the dial gauge set at end of camshaft. If the clearance is not within the standard or there is offset wear, replace the camshaft caps and cylinder head as a set. If necessary replace the camshaft.

Camshaft thrust clearance:

Standard

Intake

0.075 - 0.135 mm (0.0030 - 0.0053 in)

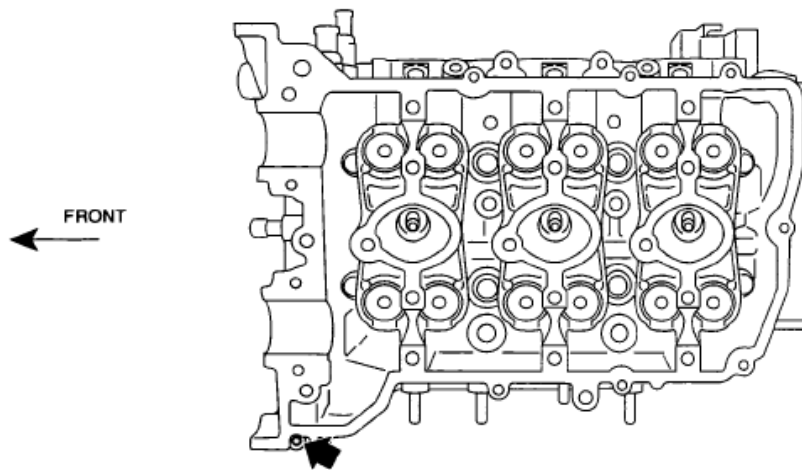
Exhaust

0.075 - 0.135 mm (0.0030 - 0.0053 in)

CYLINDER HEAD

REMOVAL

1. Remove the engine from vehicle. Ref. to **REMOVAL**, Engine Assembly.
2. Remove the crank pulley. Ref. to **REMOVAL**, Crank Pulley.
3. Remove the chain cover. Ref. to **REMOVAL**, Chain Cover.
4. Remove the timing chain assembly. Ref. to **REMOVAL**, Timing Chain Assembly.
5. Remove the cam sprocket. Ref. to **REMOVAL**, Cam Sprocket.
6. Remove the crank sprocket. Ref. to **REMOVAL**, Crank Sprocket.
7. Remove the camshaft. Ref. to **REMOVAL**, Camshaft.
8. Remove the seal bolt shown in the figure.



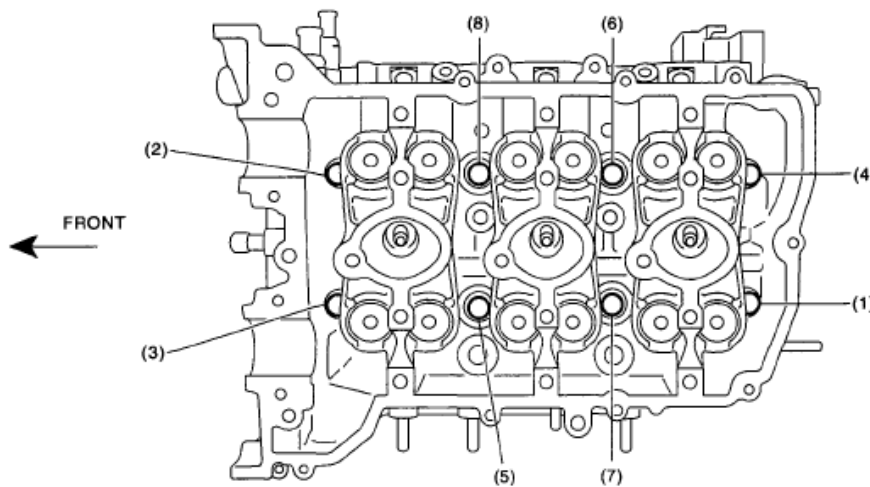
ME-03524

Fig. 190: Locating Seal Bolt

Courtesy of SUBARU OF AMERICA, INC.

9. Remove the cylinder head bolts in the numerical order as shown in the figure.

NOTE: Leave bolts (2) and (4) engaged by three or four threads to prevent the cylinder head from falling.



ME-03415

Fig. 191: Identifying Cylinder Head Bolts In Sequence

Courtesy of SUBARU OF AMERICA, INC.

10. While tapping the cylinder head with a plastic hammer, separate it from cylinder block.
11. Remove the bolts (2) and (4) to remove cylinder head.
12. Remove the cylinder head gasket.

CAUTION: Be careful not to scratch the mating surface of cylinder head and cylinder block.

13. Similarly, remove the cylinder head (RH).

INSTALLATION

1. Apply liquid gasket to the mating surface of cylinder block shown in the figure.

NOTE:

- **Install within 5 min. after applying liquid gasket.**
- **Do not apply liquid gasket excessively. If too much is applied, remove any liquid gasket that is squeezed out.**

Liquid gasket:

THREE BOND 1217G (Part No. K0877Y0100) or equivalent

Liquid gasket applying diameter:

3.5±1.0 mm (0.138±0.039 in)

- LH side

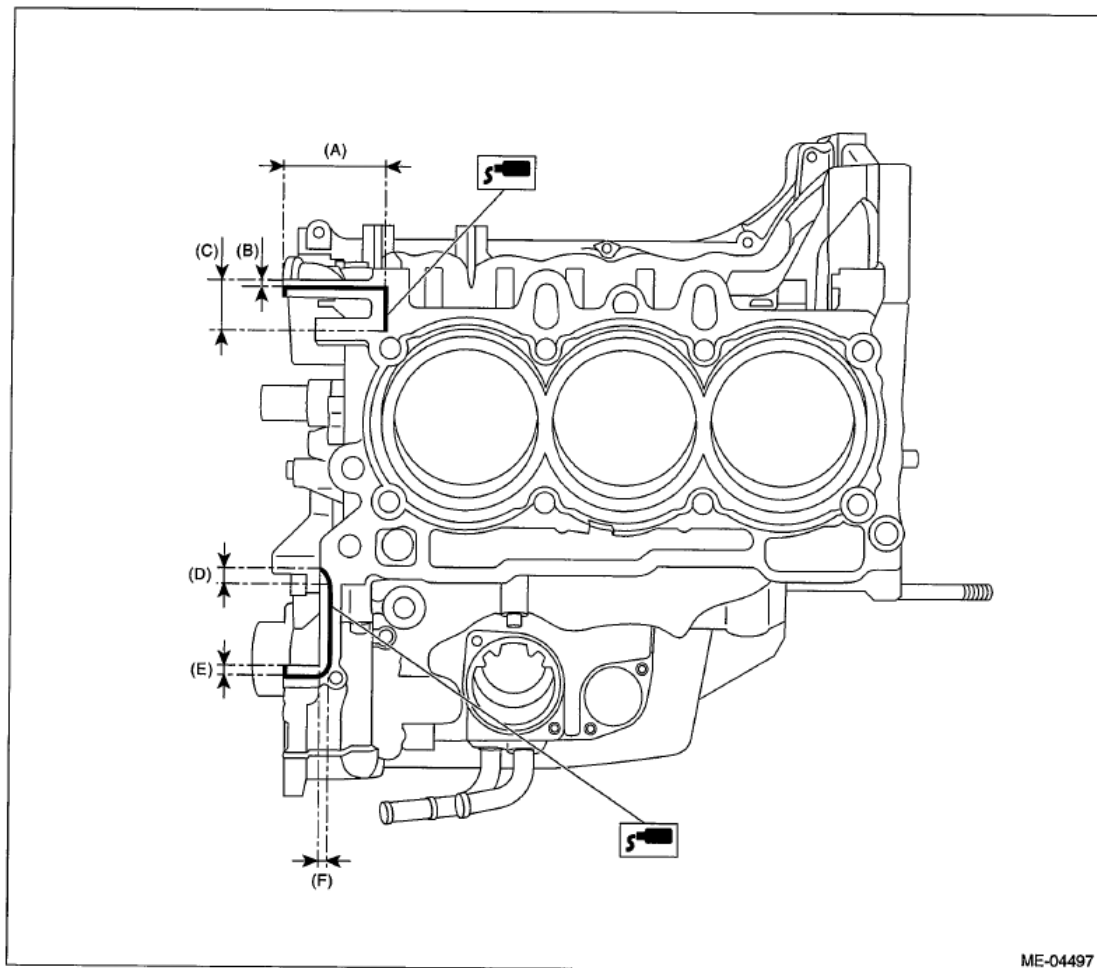
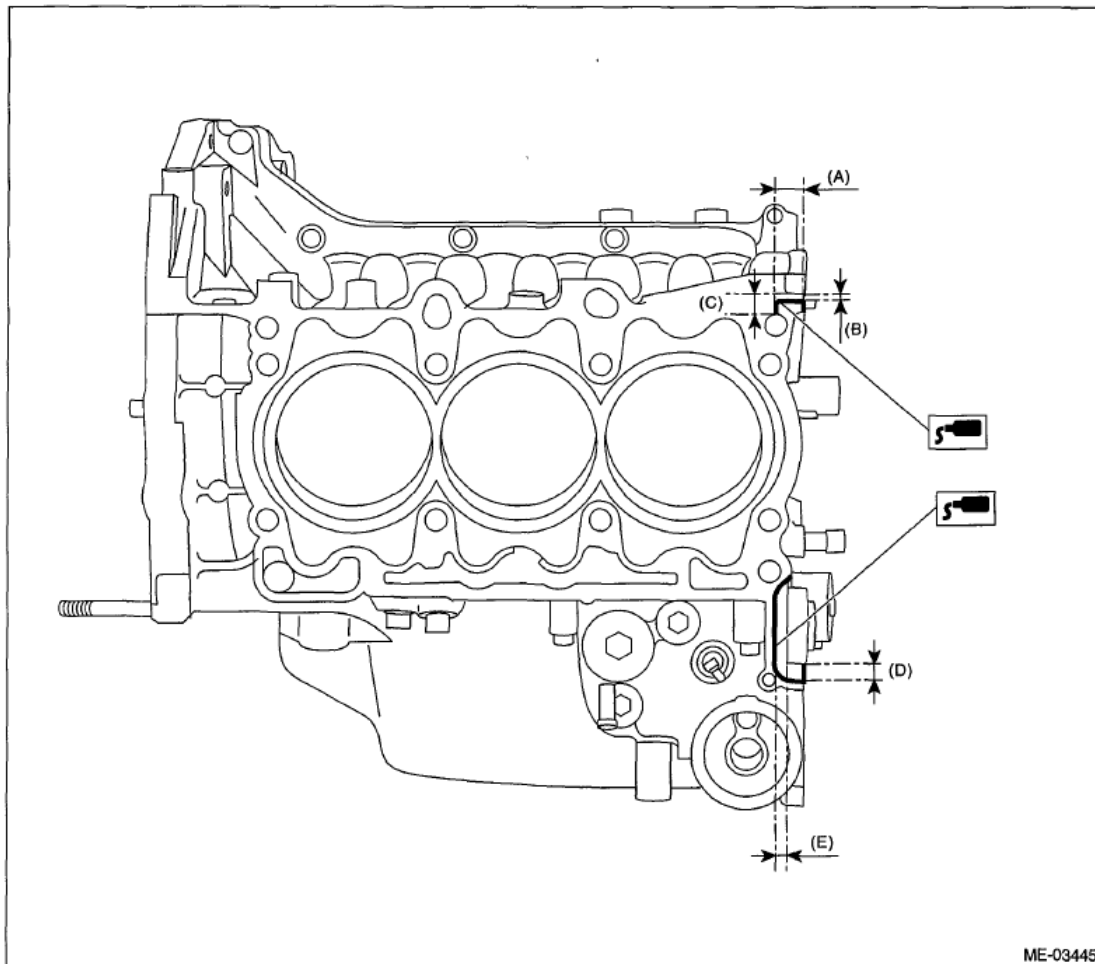


Fig. 192: Identifying Liquid Gasket Applying Area On Cylinder Block (LH Side)
Courtesy of SUBARU OF AMERICA, INC.

- RH side



(A) 17 mm (0.669 in)

(B) 2 mm (0.079 in)

(C) 9 mm (0.354 in)

(D) 4 mm (0.157 in)

(E) 4 mm (0.157 in)

Fig. 193: Identifying Liquid Gasket Applying Area On Cylinder Block (RH Side)
Courtesy of SUBARU OF AMERICA, INC.

2. Install the cylinder head gaskets LH and RH onto the cylinder block.

NOTE: Use a new cylinder head gasket.

3. Apply liquid gasket to the mating surface of cylinder head gasket shown in the figure.

NOTE:

- Install within 5 min. after applying liquid gasket.
- Do not apply liquid gasket excessively. If too much is applied, remove any liquid gasket that is squeezed out.

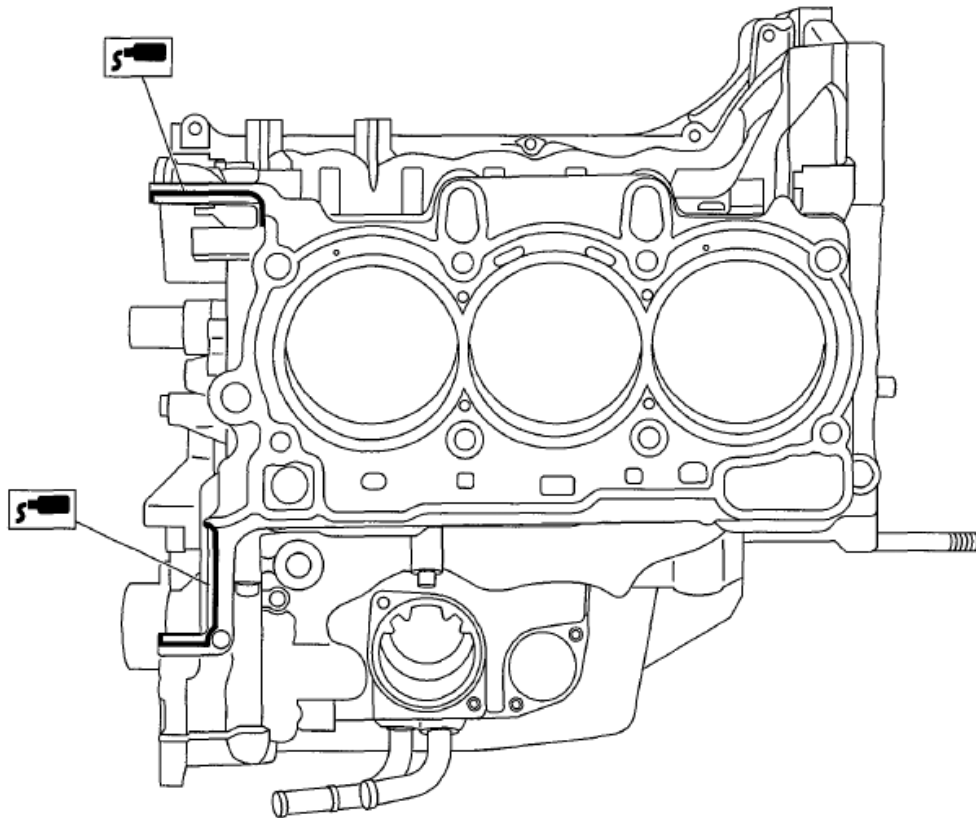
Liquid gasket:

THREE BOND 1217G (Part No. K0877Y0100) or equivalent

Liquid gasket applying diameter:

3.5±1.0 mm (0.138±0.039 in)

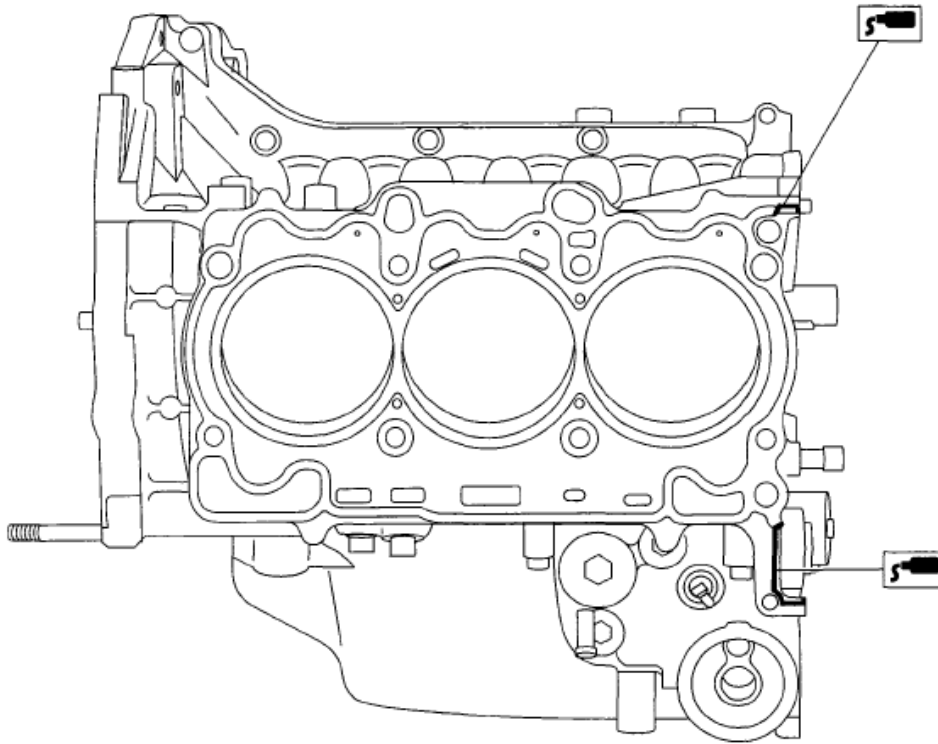
- LH side



ME-04498

Fig. 194: Identifying Liquid Gasket Applying Area On Cylinder Head Gasket (LH Side)
Courtesy of SUBARU OF AMERICA, INC.

- RH side



ME-03544

Fig. 195: Identifying Liquid Gasket Applying Area On Cylinder Head Gasket (R Side)
Courtesy of SUBARU OF AMERICA, INC.

4. Attach the cylinder head to the cylinder block.

CAUTION: Be careful not to scratch the mating surface of cylinder head and cylinder block.

5. Tighten the cylinder head bolts.
 1. Apply a thin coat of engine oil to washers and cylinder head bolt threads.
 2. Mount the cylinder head onto the cylinder block, then tighten the bolts with a torque of 20 N.m (2.0 kgf-m, 14.8 ft-lb) in the order indicated in the figure.
 3. Tighten the bolts with a torque of 50 N.m (5.1 kgf-m, 36.9 ft-lb) in the order indicated in the figure.
 4. Loosen all bolts by 180° in the reverse order of installing, and loosen them further by 180°.
 5. Tighten the bolts with torque of 20 N.m (2.0 kgf-m, 14.8 ft-lb) in numerical sequence as shown in the figure.
 6. Tighten the bolts (1) - (4) in the order indicated with a torque of 48 N.m (4.9 kgf-m, 35.4 ft-lb).
 7. Tighten the bolts (5) - (8) in the order indicated with a torque of 44 N.m (4.5 kgf-m, 32.5 ft-lb).
 8. Tighten all bolts 90° in the numerical order as shown in the figure.

9. Tighten the bolt (1) - (4) by 45° in the numerical order.

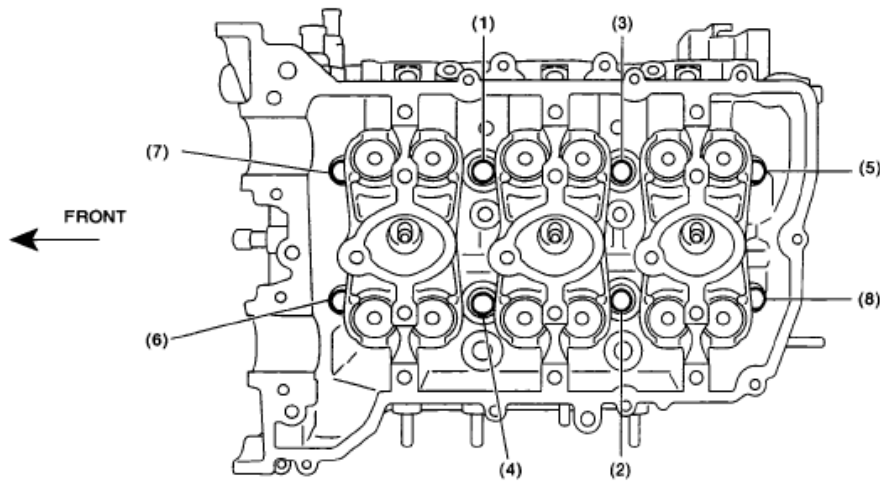


Fig. 196: Identifying Cylinder Head Bolts In Tightening Sequence
Courtesy of SUBARU OF AMERICA, INC.

6. Install the seal bolt shown in the figure.

NOTE: Before installing seal bolts, apply a sealing material to bolt threads.

SEAL MATERIAL:

THREE BOND 1324 (Part No. 004403042) or equivalent

Tightening torque:

6.4 N.m (0.7 kgf-m, 4.7 ft-lb)

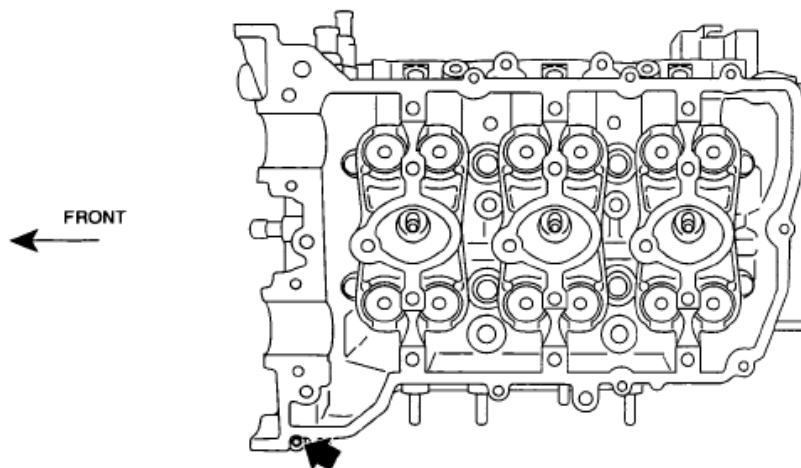


Fig. 197: Locating Seal Bolt

Courtesy of SUBARU OF AMERICA, INC.

7. Install the camshaft. Ref. to **INSTALLATION**, Camshaft.
8. Install the crank sprocket. Ref. to **INSTALLATION**, Crank Sprocket.
9. Install the cam sprocket. Ref. to **INSTALLATION**, Cam Sprocket.
10. Install the timing chain assembly. Ref. to **INSTALLATION**, Timing Chain Assembly.
11. Install the chain cover. Ref. to **INSTALLATION**, Chain Cover.
12. Install the crank pulley. Ref. to **INSTALLATION**, Crank Pulley.
13. Install the engine to the vehicle. Ref. to **INSTALLATION**, Engine Assembly.

DISASSEMBLY

1. Set the cylinder head on ST.

ST 18250AA010 CYLINDER HEAD TABLE

2. Remove the valve lifter.
3. Compress the valve spring using ST, and remove the valve spring retainer key, each valve and valve spring.

ST 499718000 VALVE SPRING REMOVER

NOTE:

- **Mark each valve to prevent confusion.**
- **Pay careful attention not to damage the lips of intake valve oil seals and exhaust valve oil seals.**
- **Keep all the removed parts in order for re-installing in their original positions.**
- **For removal and installation procedures of the valve guide, intake valve oil seal and exhaust valve oil seal, refer to "INSPECTION". Ref. to **VALVE GUIDE**, **INSPECTION**, Cylinder Head. Ref. to **INTAKE AND EXHAUST VALVE OIL SEAL**, **INSPECTION**, Cylinder Head.**

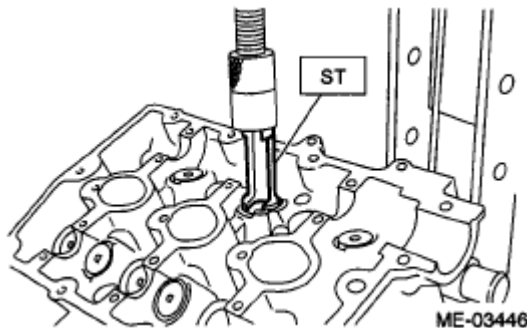


Fig. 198: Compressing Valve Spring Using ST
Courtesy of SUBARU OF AMERICA, INC.

ASSEMBLY

1. Install the valve spring and valve.
 1. Set the cylinder head on ST.

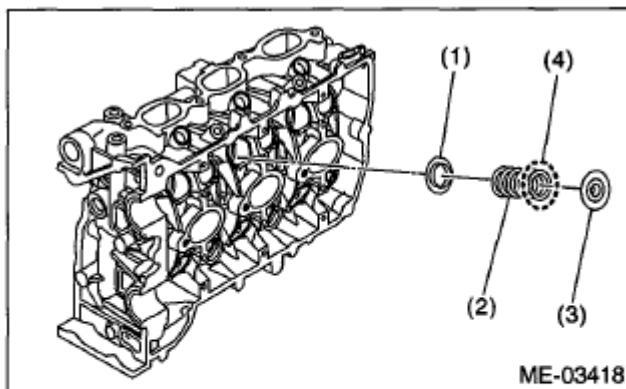
ST 18250AA010 CYLINDER HEAD TABLE

2. Coat the stem of each valve with engine oil and insert the valve into valve guide.

NOTE: When inserting the valve into valve guide, use special care not to damage the oil seal lip.

3. Install the valve spring and retainer.

- NOTE:**
- Be sure to install the valve spring with its close-coiled end facing the seat on cylinder head.
 - Install the valve spring with the painted side facing to retainer.



- (1) Seat
- (2) Valve spring
- (3) Retainer
- (4) Painted face

Fig. 199: Identifying Seat, Valve Spring, Retainer And Painted Face
Courtesy of SUBARU OF AMERICA, INC.

4. Set the ST on valve spring.

ST 499718000 VALVE SPRING REMOVER

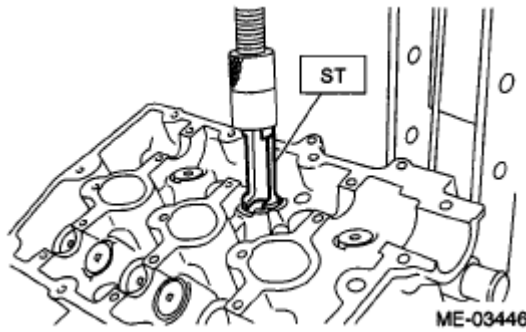


Fig. 200: Compressing Valve Spring Using ST
Courtesy of SUBARU OF AMERICA, INC.

5. Compress the valve spring and fit the valve spring retainer key.
6. After installing, tap the valve spring retainers lightly with a wooden hammer for better seating.
2. Apply oil to the surface of valve lifter.
3. Install the valve lifter.

INSPECTION

CYLINDER HEAD

1. Make sure that there are no cracks or other damages. Perform visual check, and use liquid penetrant tester on the important sections. Check that there are no marks of gas leaking or water leaking on gasket installing surface.
2. Set the cylinder head on ST.

ST 18250AA010 CYLINDER HEAD TABLE

3. Check for warpage at mating surface between the cylinder block and cylinder head using a straight edge (A) and thickness gauge (B). If the warpage exceeds limit, replace the cylinder head.

Warping limit:

0.020 mm (0.0008 in)

Standard height of cylinder head:

124±0.05 mm (4.88±0.0020 in)

NOTE: Uneven torque for the cylinder head bolts can cause warpage. When reinstalling, pay special attention to the torque so as to tighten evenly.

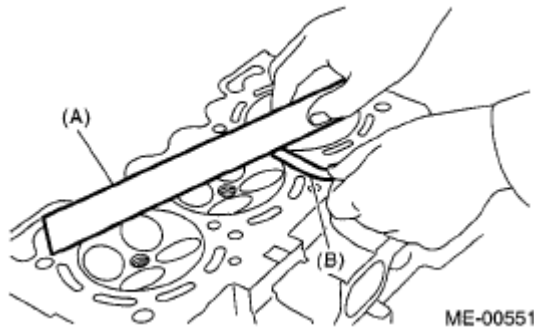


Fig. 201: Checking Cylinder Head Warpage
Courtesy of SUBARU OF AMERICA, INC.

VALVE SEAT

Inspect the intake and exhaust valve seats, and correct the contact surfaces with a valve seat cutter if they are defective or when valve guides are replaced.

Contacting width of valve seat W :

Standard Intake

1.0 mm (0.039 in)

Exhaust

1.5 mm (0.059 in)

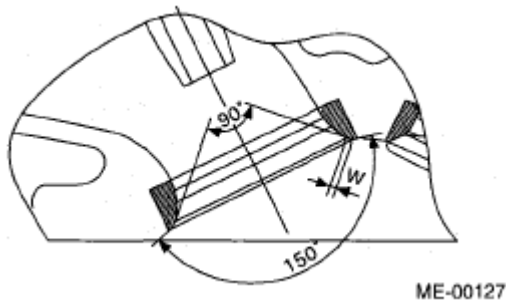


Fig. 202: Checking Valve Seat Width
Courtesy of SUBARU OF AMERICA, INC.

VALVE GUIDE

1. Check the clearance between valve guide and valve stem. The clearance can be checked by measuring respectively the outer diameter of valve stem with a micrometer and the inner diameter of valve guide with a caliper gauge.

Clearance between the valve guide and valve stem:

Standard Intake***0.030 - 0.057 mm (0.0012 - 0.0022 in)******Exhaust******0.040 - 0.067 mm (0.0016 - 0.0026 in)***

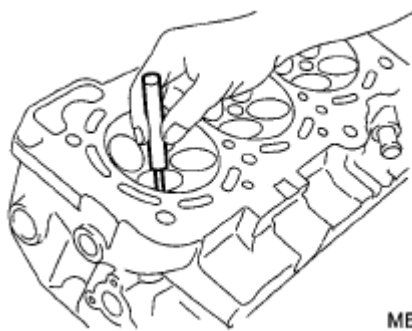
2. If the clearance between valve guide and valve stem exceeds the standard, replace the valve guide or valve itself, whichever shows the greater amount of wear or damage. See the following procedure for valve guide replacement.

Valve guide inner diameter:***5.500 - 5.512 mm (0.2165 - 0.2170 in)******Valve stem outer diameters:******Intake******5.455 - 5.470 mm (0.2148 - 0.2154 in)******Exhaust******5.445 - 5.460 mm (0.2144 - 0.2150 in)***

1. Place the cylinder head on ST1 with the combustion chamber upward so that valve guides fit the holes in ST1.
2. Insert the ST2 into valve guide and press it down to remove the valve guide.

ST1 18250AA010 CYLINDER HEAD TABLE

ST2 499765700 VALVE GUIDE REMOVER



ME-00553

Fig. 203: Checking Clearance Between Valve Guide And Valve Stem
Courtesy of SUBARU OF AMERICA, INC.

3. Turn the cylinder head upside down and place the ST as shown in the figure.

ST 18251AA050 VALVE GUIDE ADJUSTER (INTAKE SIDE)

ST 18251AA060 VALVE GUIDE ADJUSTER (EXHAUST SIDE)

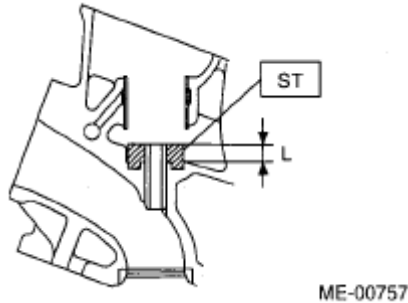


Fig. 204: Identifying Valve Guide Adjuster ST 18251AA020 On Cylinder Head
Courtesy of SUBARU OF AMERICA, INC.

4. Before installing a new valve guide, make sure that neither scratches nor damages exist on the inner surface of valve guide holes in cylinder head.
5. Coat a new valve guide with sufficient oil, put it into the cylinder, and insert the ST1 into the valve guide. Press in until the valve guide upper end is flush with the upper surface of ST2.

ST1 499765700 VALVE GUIDE REMOVER

ST2 18251AA050 VALVE GUIDE ADJUSTER (INTAKE SIDE)

ST2 18251AA060 VALVE GUIDE ADJUSTER (EXHAUST SIDE)

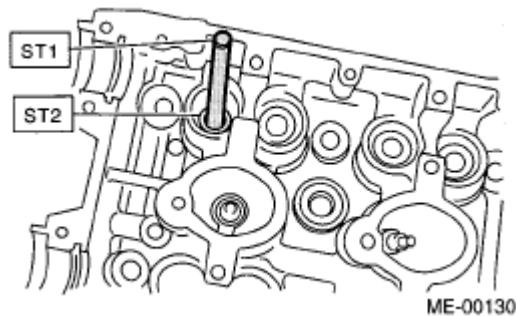


Fig. 205: Identifying Valve Guide Remover ST1 499767200 And Valve Guide Adjuster ST2 18251AA020
Courtesy of SUBARU OF AMERICA, INC.

6. Check the valve guide protrusion amount

Valve guide protrusion amount L:

Intake***8.6 - 9.0 mm (0.3386 - 0.3543 in)******Exhaust******10.7-11.1 mm (0.4213 - 0.4370 in)***

7. Ream the inside of valve guide using ST. Put the reamer in valve guide, and slowly rotate the reamer clockwise while pushing it lightly. Bring the reamer back while rotating it clockwise.

ST 499765900 VALVE GUIDE REAMER

NOTE:

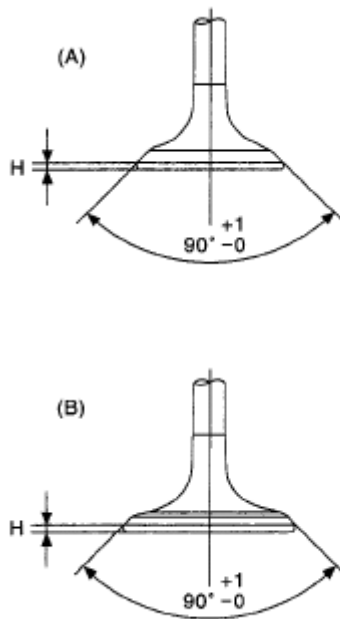
- Apply engine oil to the reamer when reaming.
- If the inner surface of valve guide is damaged, the edge of reamer should be slightly ground with oil stone.
- If the inner surface of valve guide becomes lustrous and the reamer does not chip, use a new reamer or remedy the reamer.

8. After reaming, clean the valve guide to remove chips.
9. Recheck the contact condition between valve and valve seat after replacing the valve guide.

INTAKE AND EXHAUST VALVE

1. Inspect the flange and stem of valve, and replace if damaged, worn or deformed, "H" exceeds the standard, or if there is uneven wear.

Head edge thickness H:***Standard******Intake (A)******1.0 mm (0.039 in)******Exhaust (B)******1.2 mm (0.047 in)***



ME-02096

Fig. 206: Checking Head Edge Thickness
 Courtesy of SUBARU OF AMERICA, INC.

- Put a small amount of grinding compound on the seat surface, and lap the valve and seat surface. Install a new valve oil seal after lapping.

NOTE: It is possible to differentiate between the intake valve and the exhaust valve by their overall length.

Valve overall length:

Intake

103.5 mm (4.075 in)

Exhaust

103.2 mm (4.063 in)

VALVE SPRING

- Check the valve springs for damage, free length, and tension. Replace the valve spring if it is not within the standard value presented in the table.
- To measure the squareness of the valve spring, stand the valve spring on a surface plate and measure its deflection at the top of the spring using a try square.

VALVE SPRING SPECIFICATION CHART

--	--

Free length mm (in)		49.06 (1.9315)
Tension/spring height N (kgf, lb)/mm (in)	Set	182 - 210 (18.6 - 21.4, 40.9 - 47.2)/31.0 (1.220 in)
	Lift	316 - 350 (32.2 - 35.7, 71.0 - 78.7)/21.0 (0.827 in)
Squareness		2.5°, 2.1 mm (0.083 in) or less

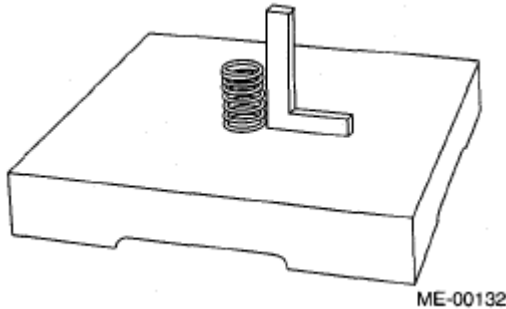


Fig. 207: Measuring Squareness Of Valve Spring
Courtesy of SUBARU OF AMERICA, INC.

INTAKE AND EXHAUST VALVE OIL SEAL

- For the following, replace the oil seal with a new part.
 - When the lip is damaged.
 - When the spring is out of the specified position.
 - When readjusting the surfaces of valve and valve seat.
 - When replacing the valve guide.
- Set the cylinder head on ST1.
- Using the ST2, press in the oil seal.

ST1 18250AA010 CYLINDER HEAD TABLE

ST2 499585500 VALVE OIL SEAL GUIDE

NOTE:

- Apply engine oil to oil seal before press-fitting.
- When press-fitting the oil seal, do not use a hammer or strike in.

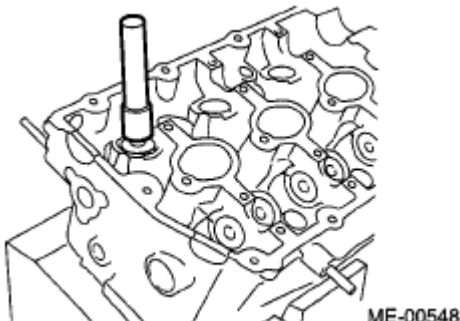


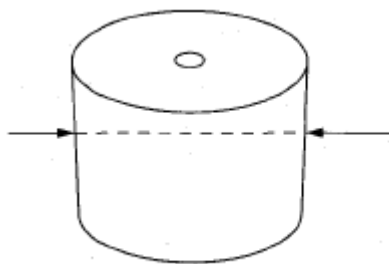
Fig. 208: Installing Valve Oil Seal
Courtesy of SUBARU OF AMERICA, INC.

VALVE LIFTER

1. Perform visual check on the valve lifter.
2. Measure the valve lifter outer diameter.

Outer diameter of valve lifter:

32.959 - 32.975 mm (1.2976 - 1.2982 in)



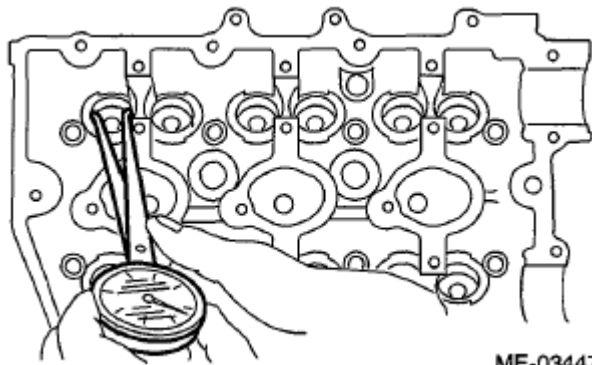
ME-00134

Fig. 209: Checking Outer Diameter Of Valve Lifter
Courtesy of SUBARU OF AMERICA, INC.

3. Measure the inner diameter of valve lifter hole of cylinder head.

Inner diameter of valve lifter mating surface:

32.994 - 33.016 mm (1.2990 - 1.2998 in)



ME-03447

Fig. 210: Measuring Inner Diameter Of Valve Lifter Hole Of Cylinder Head
Courtesy of SUBARU OF AMERICA, INC.

4. Check the clearance between valve lifter and valve lifter mating surface. The clearance can be determined from the measured value of the valve lifter outer diameter and valve lifter mating surface inner diameter. If it is not within the standard or there is uneven wear in the inner surface, replace the cylinder head.

Clearance between valve lifter and valve lifter mating surface:

Standard

0.019 - 0.057 mm (0.0007 - 0.0022 in)

CYLINDER BLOCK

REMOVAL

NOTE: Before conducting this procedure, drain the engine oil completely.

1. Remove the engine from vehicle. Ref. to **REMOVAL**, Engine Assembly.
2. Remove the crank pulley. Ref. to **REMOVAL**, Crank Pulley.
3. Remove the chain cover. Ref. to **REMOVAL**, Chain Cover.
4. Remove the timing chain assembly. Ref. to **REMOVAL**, Timing Chain Assembly.
5. Remove the cam sprocket. Ref. to **REMOVAL**, Cam Sprocket.
6. Remove the crank sprocket. Ref. to **REMOVAL**, Crank Sprocket.
7. Remove the camshaft. Ref. to **REMOVAL**, Camshaft.
8. Remove the cylinder head. Ref. to **REMOVAL**, Cylinder Head.
9. Use the ST to lock the crankshaft, and remove the drive plate.

ST 498497100 CRANKSHAFT STOPPER

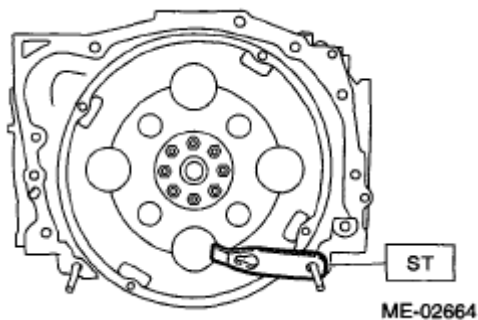


Fig. 211: Removing Drive Plate Using ST
Courtesy of SUBARU OF AMERICA, INC.

10. Remove the crankshaft position sensor.

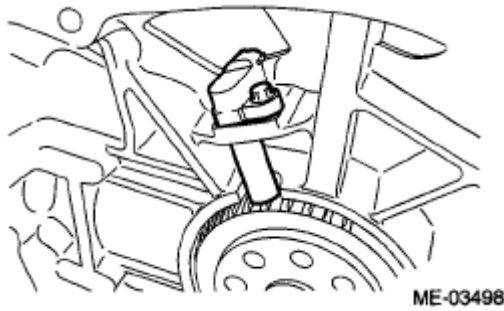


Fig. 212: Identifying Crankshaft Position Sensor
Courtesy of SUBARU OF AMERICA, INC.

11. Remove the crankshaft position sensor plate.

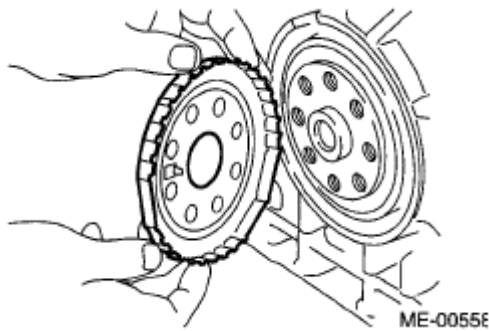


Fig. 213: Removing Crankshaft Position Sensor Plate
Courtesy of SUBARU OF AMERICA, INC.

12. Rotate the engine to set oil pan upper.
13. Remove the bolts which secure oil pan lower to oil pan upper.

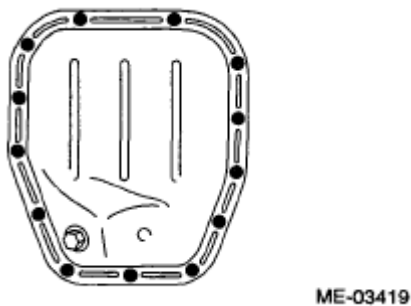
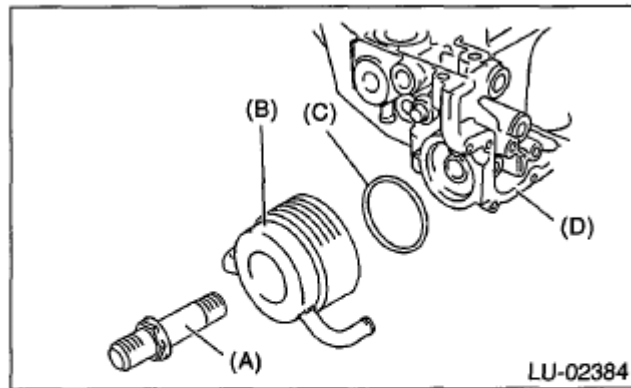


Fig. 214: Identifying Oil Pan Bolts
Courtesy of SUBARU OF AMERICA, INC.

14. Insert an oil pan cutter blade into the gap between oil pan upper and oil pan lower, and remove the oil pan lower.

CAUTION: Do not use a screwdriver or similar tools in place of oil pan cutter.

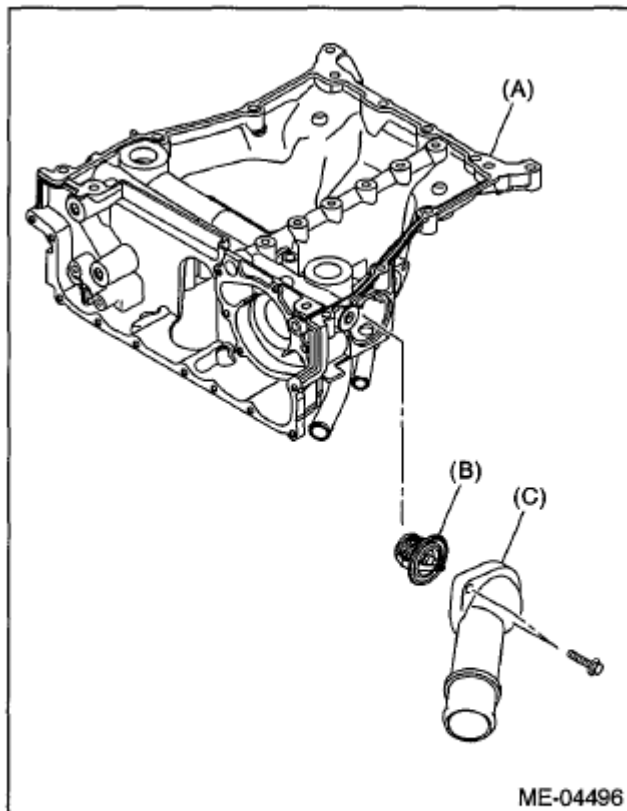
15. Remove the oil cooler connector and remove the oil cooler.



- (A) Oil cooler connector
(B) Oil cooler
(C) O-ring
(D) Oil pan upper

Fig. 215: Identifying Oil Cooler Connector, Oil Cooler, O-Ring And Oil Pan Upper
Courtesy of SUBARU OF AMERICA, INC.

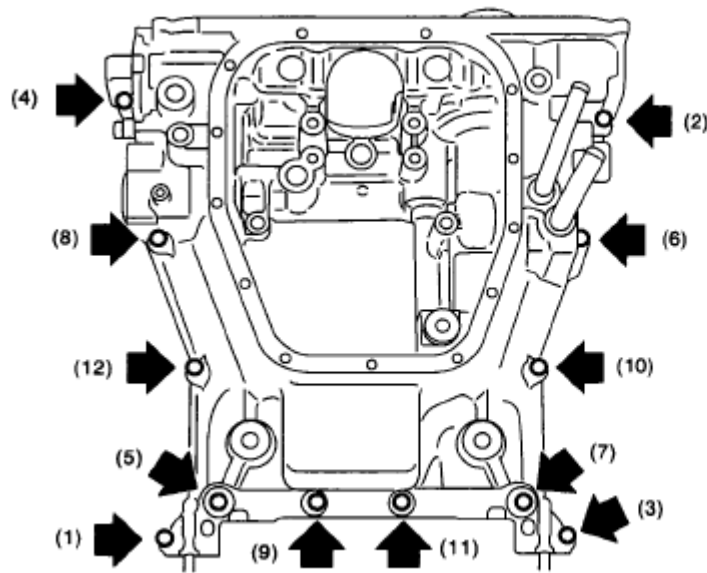
16. Remove the oil pump. Ref. to **REMOVAL** , Oil Pump.
17. Remove the oil level switch. Ref. to **REMOVAL** , Oil Level Switch.
18. Remove the thermostat cover, and then remove the thermostat.



- (A) Oil pan upper
- (B) Thermostat
- (C) Thermostat cover

Fig. 216: Identifying Oil Pan Upper, Thermostat And Thermostat Cover
Courtesy of SUBARU OF AMERICA, INC.

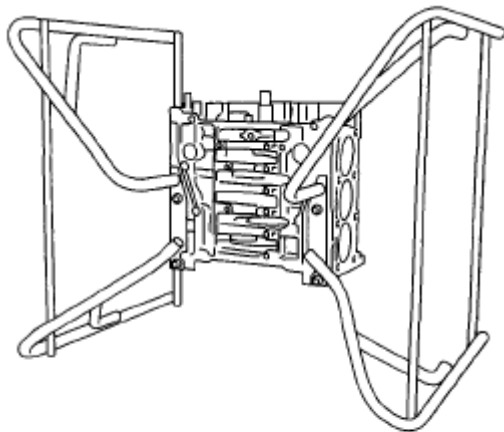
19. Remove the oil pump cover.



ME-03420

Fig. 217: Locating Oil Pump Cover Bolts In Sequence
Courtesy of SUBARU OF AMERICA, INC.

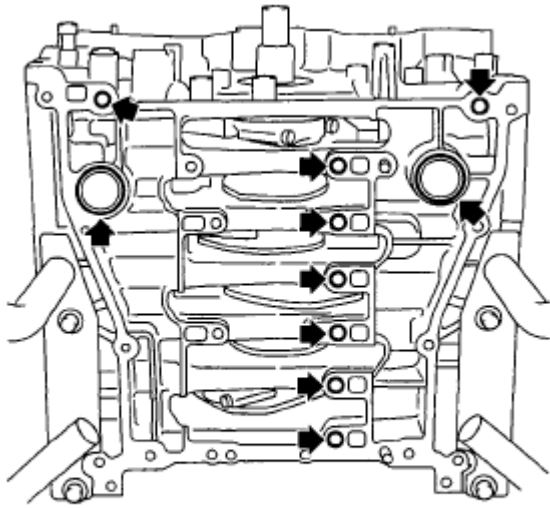
20. Face the front of the engine up, standing the engine on one end.



ME-03421

Fig. 218: Positioning Engine On Stand
Courtesy of SUBARU OF AMERICA, INC.

21. Remove ten O-rings from the underside of the cylinder block.



ME-03422

Fig. 219: Locating O-Rings To Underside Of Cylinder Block
 Courtesy of SUBARU OF AMERICA, INC.

22. Mark the direction of front and the number of connecting rod caps.
23. Remove the #1 and #4 connecting rod caps and pistons from the cylinder block.

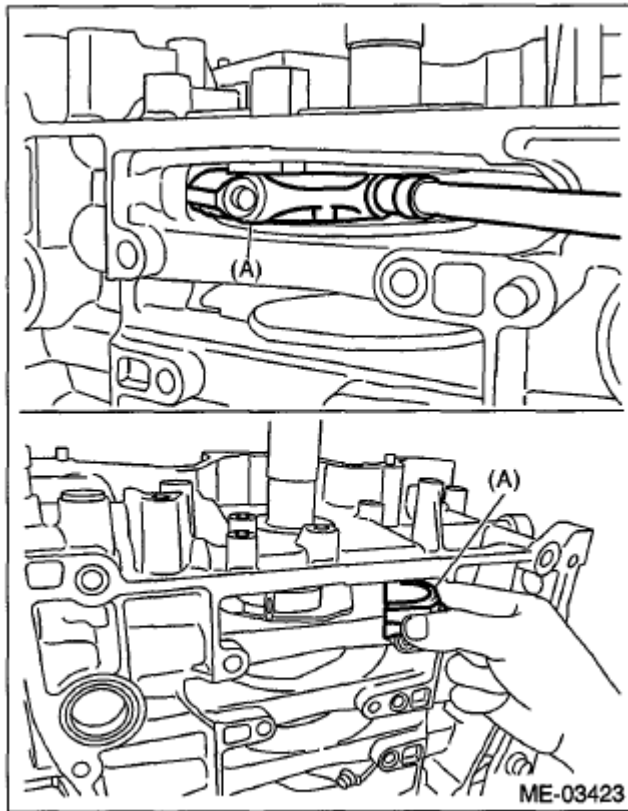
NOTE:

- Use 3/8 inch (9.5 sq.) for the extension and TORX® socket (E12).
- After removing the two connecting rod connection bolts, turning the crankshaft (ST) counterclockwise will remove the connecting rod cap.
- Mark each connecting rod cap and piston with connecting rod cap number and piston number.
- The removal of all connecting rod caps and pistons are performed in three separate steps. First, remove the #1 and #4 connecting rod caps and pistons simultaneously, then the #2 and #5 connecting rod caps and pistons simultaneously, and then the #3 and #6 connecting rod caps and pistons simultaneously.

1. Using the ST, turn the crankshaft and set the #1 piston at the mid point between TDC and BDC.

ST 18252AA000 CRANKSHAFT SOCKET

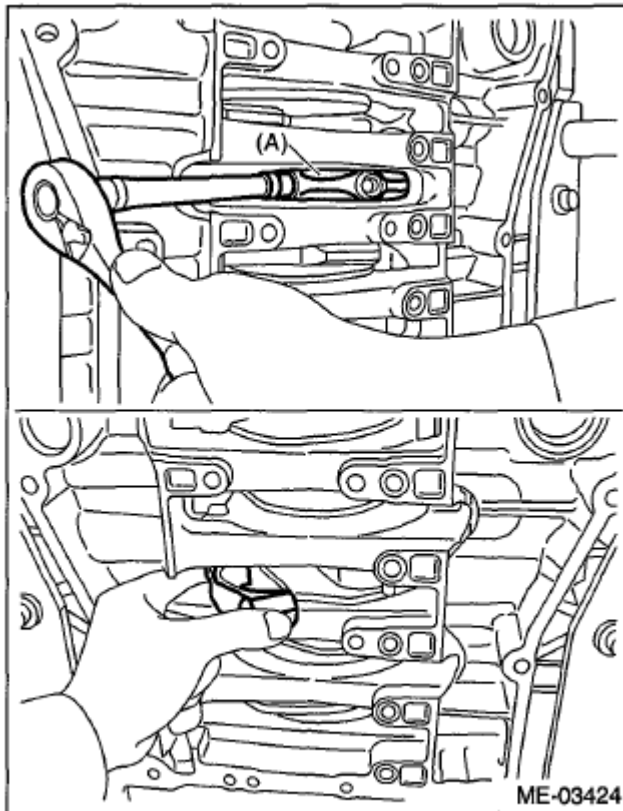
2. Remove the two #1 connecting rod cap connection bolts, and remove the connecting rod cap.



(A) #1 connecting rod cap

Fig. 220: Removing #1 Connecting Rod Cap
Courtesy of SUBARU OF AMERICA, INC.

3. Remove the two #4 connecting rod cap connection bolts, and remove the connecting rod cap.

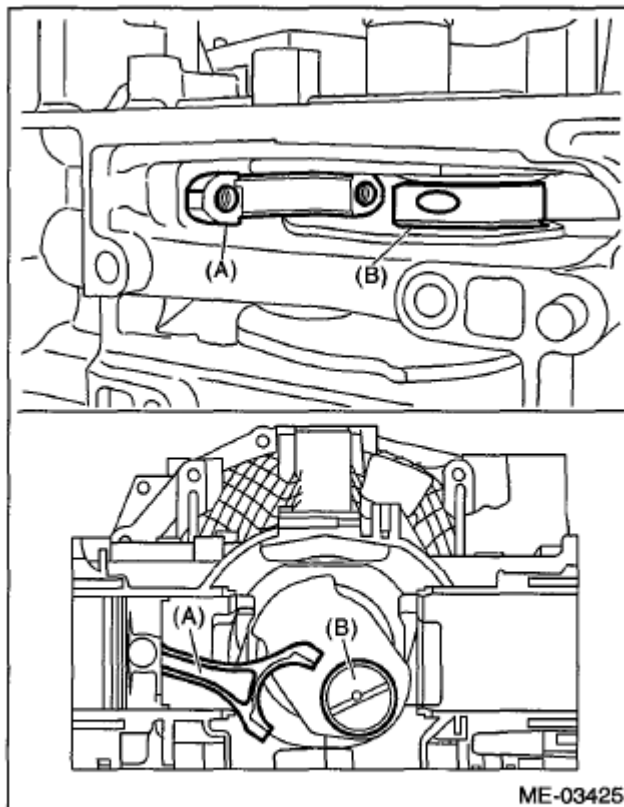


(A) #4 connecting rod cap

Fig. 221: Removing #4 Connecting Rod Cap
Courtesy of SUBARU OF AMERICA, INC.

4. Using the ST, turn the crankshaft and separate the positions of the crank pin and the large end of the #1 connecting rod.

ST 18252AA000 CRANKSHAFT SOCKET

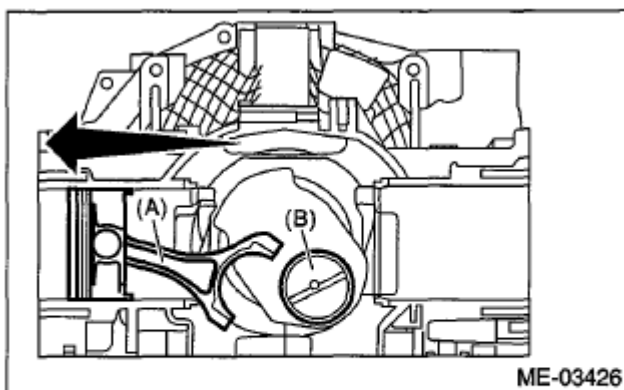


(A) #1 connecting rod

(B) Crank pin

Fig. 222: Identifying #1 Connecting Rod And Crank Pin
Courtesy of SUBARU OF AMERICA, INC.

5. Push the #1 connecting rod in the direction of the arrow, and remove the #1 piston and connecting rod from the cylinder block.



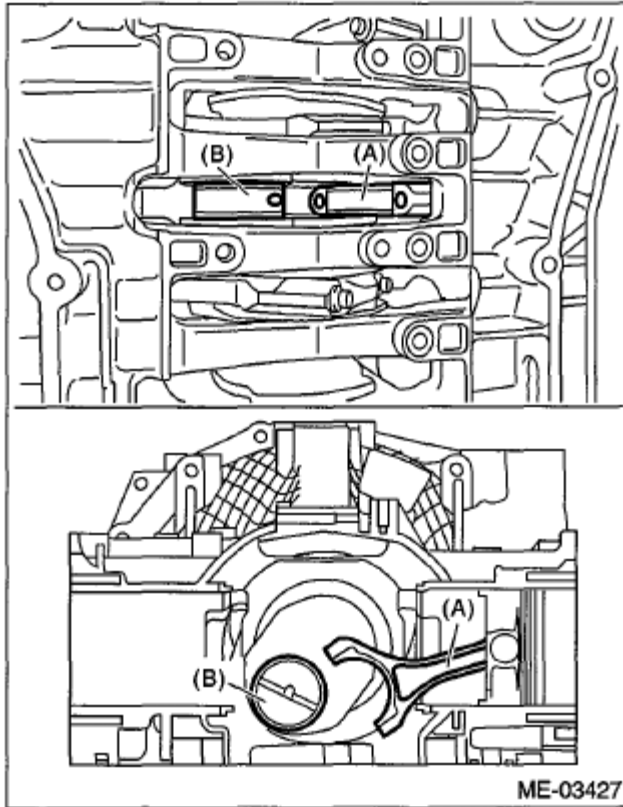
(A) #1 connecting rod

(B) Crank pin

Fig. 223: Removing #1 Piston And Connecting Rod
Courtesy of SUBARU OF AMERICA, INC.

6. Using the ST, turn the crankshaft and separate the positions of the crank pin and the large end of the #4 connecting rod.

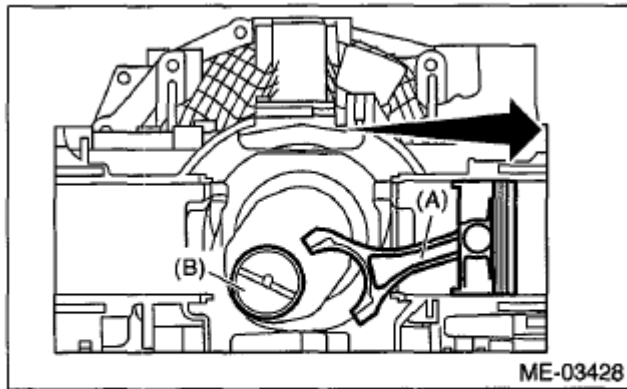
ST 18252AA000 CRANKSHAFT SOCKET



- (A) #4 connecting rod
(B) Crank pin

Fig. 224: Identifying #4 Connecting Rod And Crank Pin
Courtesy of SUBARU OF AMERICA, INC.

7. Push the #4 connecting rod in the direction 26) Face the cylinder block (RH) up. of the arrow, and remove the #4 piston and connecting rod from the cylinder block.



(A) #4 connecting rod

(B) Crank pin

Fig. 225: Removing #4 Piston And Connecting Rod
Courtesy of SUBARU OF AMERICA, INC.

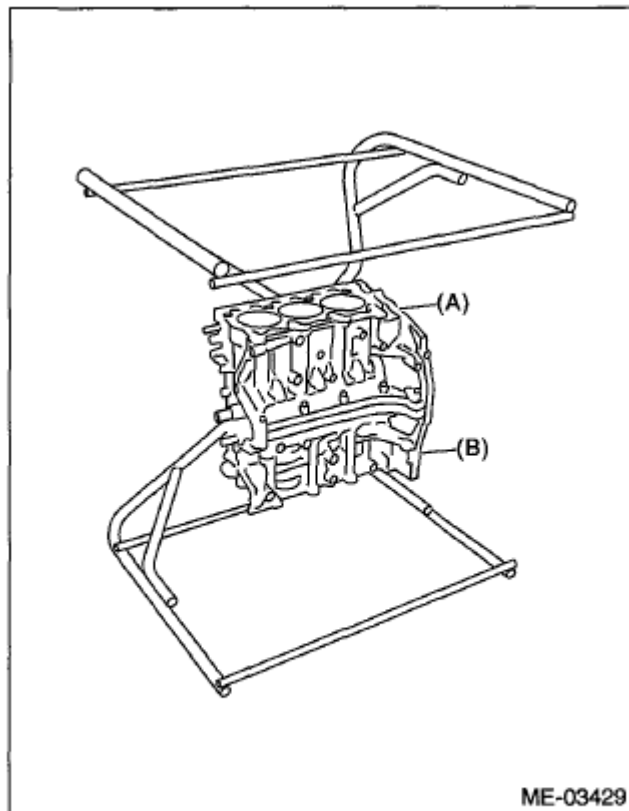
24. Remove the #2 and #5 connecting rods and pistons from the cylinder block in the same manner.

ST 18252AA000 CRANKSHAFT SOCKET

25. Remove the #3 and #6 connecting rods and pistons from the cylinder block in the same manner.

ST 18252AA000 CRANKSHAFT SOCKET

26. Face the cylinder block (RH) up.

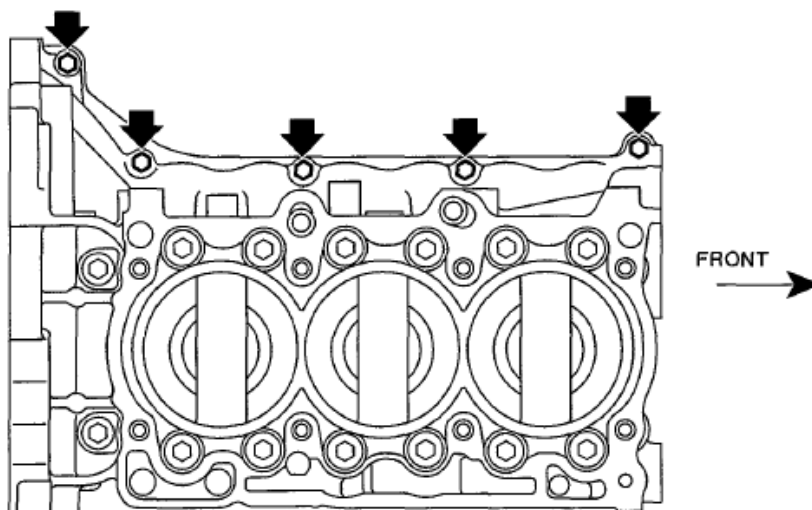


(A) Cylinder block (RH)

(B) Cylinder block (LH)

Fig. 226: Identifying Cylinder Block Position (RH)
 Courtesy of SUBARU OF AMERICA, INC.

27. Remove the upper bolt.



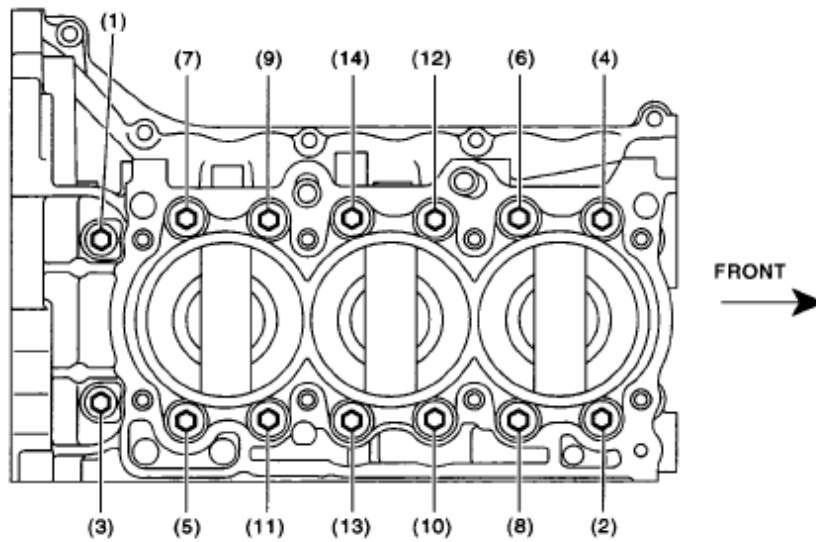
ME-03433

Fig. 227: Locating Cylinder Head Upper Bolts
 Courtesy of SUBARU OF AMERICA, INC.

28. Loosen the cylinder block bolts in the order indicated in the figure, and separate cylinder block (RH) and (LH).

NOTE: Confirm that the crankshaft is remaining in the cylinder block (LH).

If the cylinder block (RH) is lifted carelessly when separating, the crankshaft may stick to cylinder block (RH), then fall off.



ME-03430

Fig. 228: Identifying Cylinder Block Bolts Loosening Order
 Courtesy of SUBARU OF AMERICA, INC.

29. Remove the rear oil seal.
 30. Remove the crankshaft from cylinder block (LH).
 31. Remove the crankshaft bearings from cylinder block using a hammer handle.

NOTE:

- Do not confuse the combination of crankshaft bearings.
- Press the bearing at the end opposite to locking lip.

INSTALLATION

1. After setting the cylinder block to ST, install the crankshaft bearing.

ST 18232AA000 ENGINE STAND

NOTE: Apply a coat of engine oil to the bearing and crankshaft journal.

2. Mount the crankshaft in cylinder block (LH).
3. Apply liquid gasket to the mating surfaces of cylinder block (RH).

CAUTION: Do not allow liquid gasket to run over into oil passages, bearing grooves, etc.

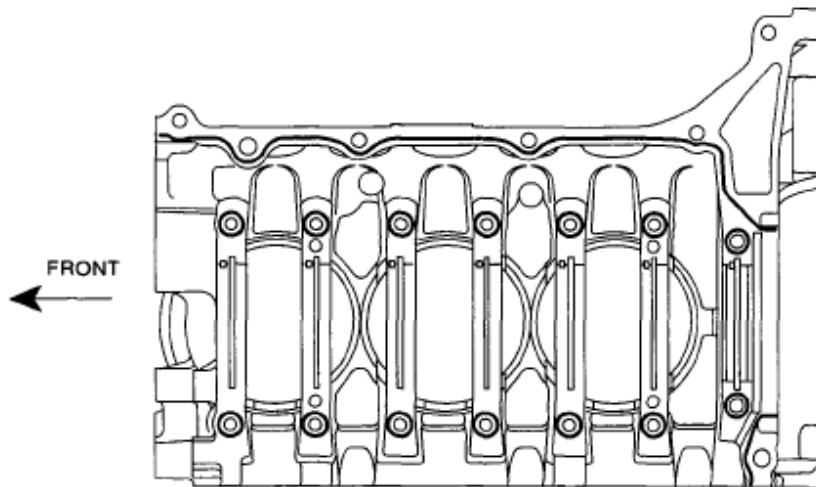
NOTE: Install within 5 min. after applying liquid gasket.

Liquid gasket:

THREE BOND 1217G (Part No. K0877Y0100) or equivalent

Liquid gasket applying diameter:

1.0±0.2 mm (0.039±0.008 in)



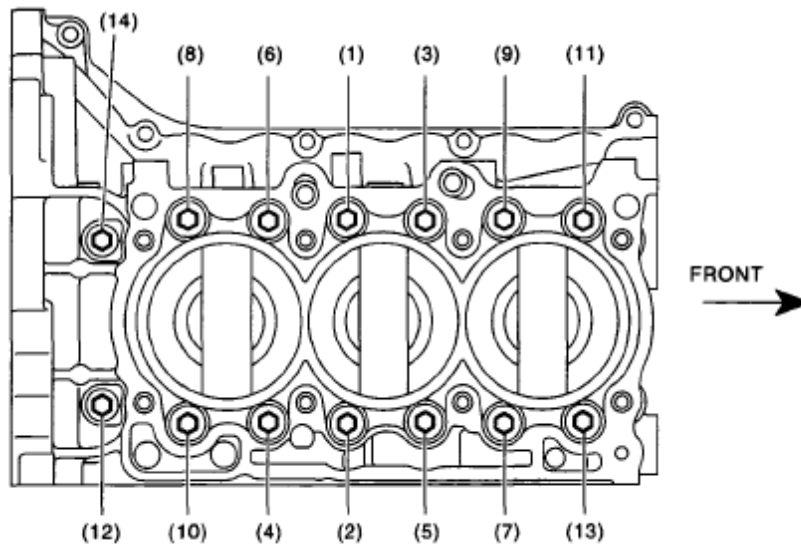
ME-03431

Fig. 229: Identifying Liquid Gasket Applying Area On Cylinder Block
Courtesy of SUBARU OF AMERICA, INC.

4. Attach cylinder block (RH) to cylinder block (LH).
5. Apply a coat of engine oil to the washer and bolt thread.
6. Tighten all bolts in the numerical order as shown in the figure.

Tightening torque:

12 N.m (1.2 kgf-m, 8.9 ft-lb)



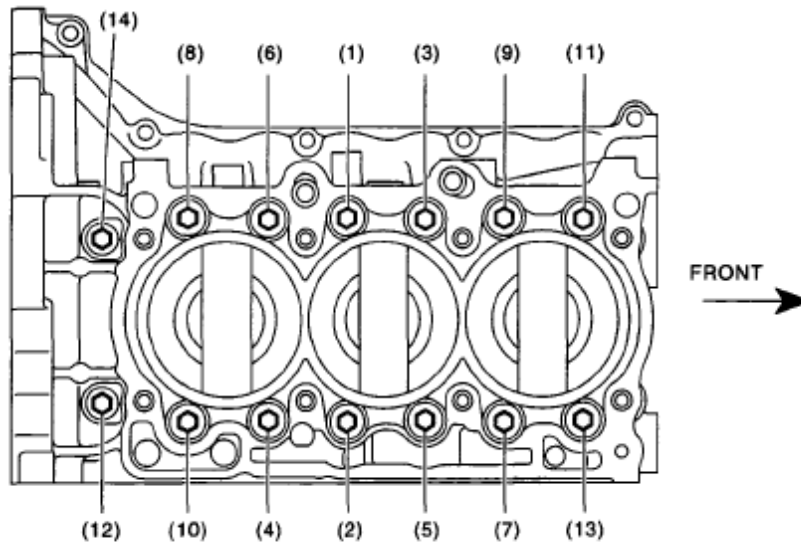
ME-03432

Fig. 230: Identifying Cylinder Block Bolts In Tightening Order
 Courtesy of SUBARU OF AMERICA, INC.

7. Retighten all bolts in the numerical order as shown in the figure.

Tightening torque:

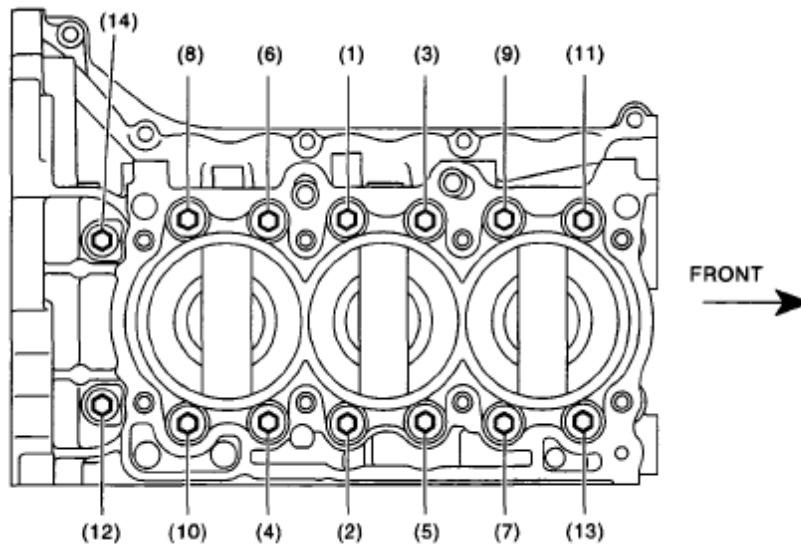
18 N.m (1.8 kgf-m, 13.3 ft-lb)



ME-03432

Fig. 231: Identifying Cylinder Block Bolts In Tightening Order
 Courtesy of SUBARU OF AMERICA, INC.

8. Tighten all bolts by 90° in numerical order as shown in the figure.



ME-03432

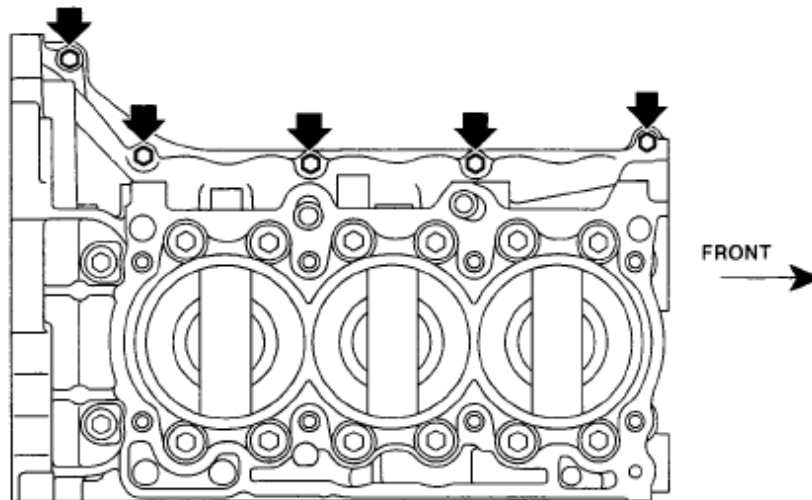
Fig. 232: Identifying Cylinder Block Bolts In Tightening Order
Courtesy of SUBARU OF AMERICA, INC.

9. Install the upper bolt to cylinder block.

Tightening torque:

25 N.m (2.5 kgf-m, 18.4 ft-lb)

NOTE: Remove any liquid gasket squeezed out onto the seal surface between the chain cover and oil pan upper, after tightening the cylinder block connecting bolts.



ME-03433

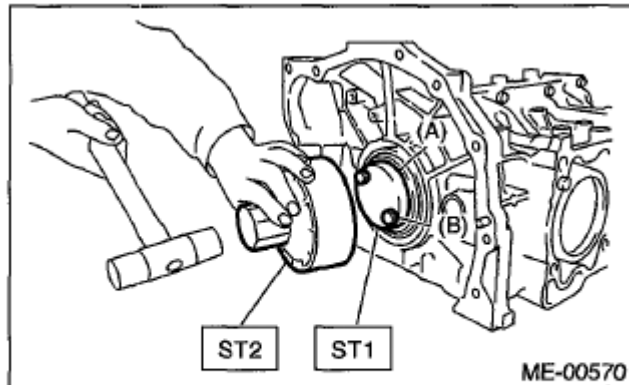
Fig. 233: Locating Cylinder Block Upper Bolts
Courtesy of SUBARU OF AMERICA, INC.

10. Apply a coat of engine oil to the oil seal periphery and install the rear oil seal using ST1 and ST2.

NOTE: Use a new rear oil seal.

ST1 499597100 CRANKSHAFT OIL SEAL GUIDE

ST2 499587200 CRANKSHAFT OIL SEAL INSTALLER

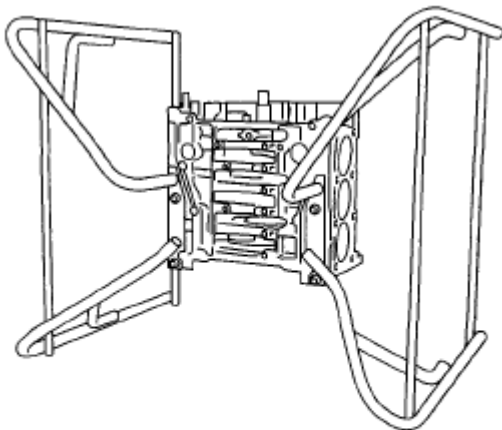


(A) Rear oil seal

(B) Drive plate installation bolt

Fig. 234: Installing Rear Oil Seal Using ST1 And ST2
Courtesy of SUBARU OF AMERICA, INC.

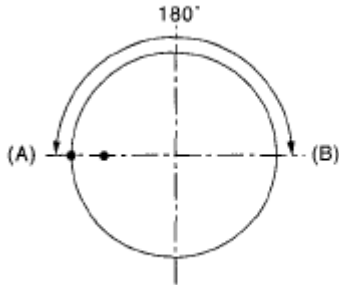
11. Face the front of the engine up, standing the engine on one end.



ME-03421

Fig. 235: Positioning Engine On Stand
Courtesy of SUBARU OF AMERICA, INC.

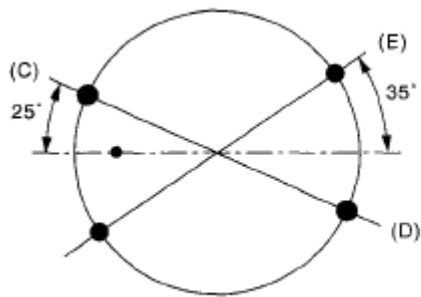
12. Attach the piston ring and oil ring to the piston.
 1. Position the top ring gap at (A) in the figure.
 2. Position the second ring gap at (B).



ME-02066

Fig. 236: Positioning Top And Second Ring Gap
 Courtesy of SUBARU OF AMERICA, INC.

3. Position the upper rail gap at (C) in the figure.
4. Position the expander gap at (D) in the figure.
5. Position the lower rail gap at (E) in the figure.



ME-02067

Fig. 237: Positioning Upper And Lower Rail Gap
 Courtesy of SUBARU OF AMERICA, INC.

CAUTION:

- Make sure ring gaps do not face the same direction.
- Make sure ring gaps are not within the piston skirt area.
- Assemble so that the stamp mark N faces towards the top of the piston.

13. Install the #1 piston and connecting rod to the cylinder block.
 1. Apply engine oil to the outer circumference of the piston and in the cylinder block.
 2. Face the front mark of piston (A) towards the front of the engine, and set the piston to the ST.

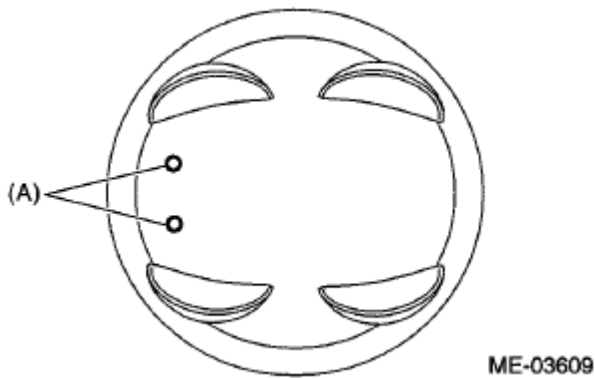


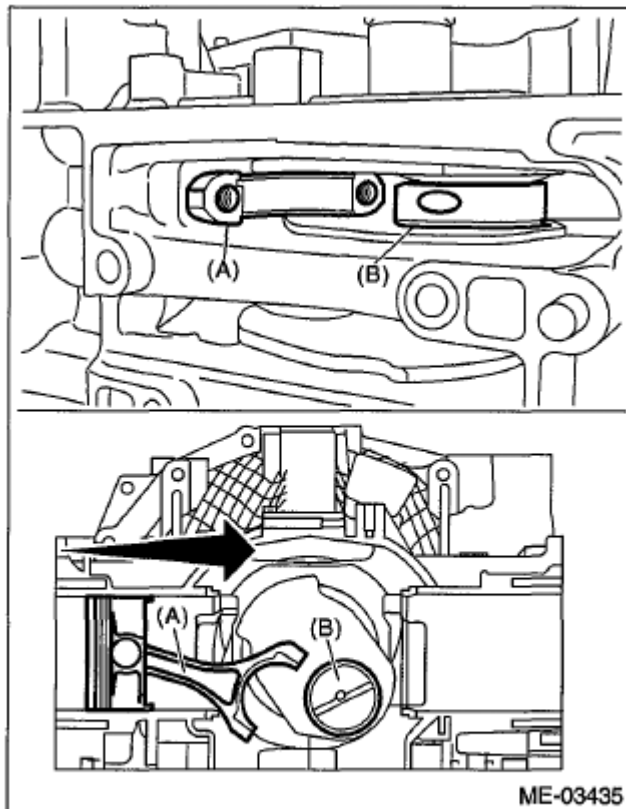
Fig. 238: Identifying Front Mark Of Piston
Courtesy of SUBARU OF AMERICA, INC.

3. Using ST, press-fit the piston into cylinder block.

NOTE: When inserting the piston into the cylinder block, perform according to the items listed below.

- Insert while lightly tapping the top of the piston with the handle of a plastic hammer.
- Insert while making sure that the large end of the connecting rod does not scratch the cylinder liner.
- Insert while continually making sure that the large end of the connecting rod does not touch the crankshaft.

ST 398744300 PISTON GUIDE



- (A) #1 connecting rod
- (B) Crank pin

Fig. 239: Installing Piston Into Cylinder Block
 Courtesy of SUBARU OF AMERICA, INC.

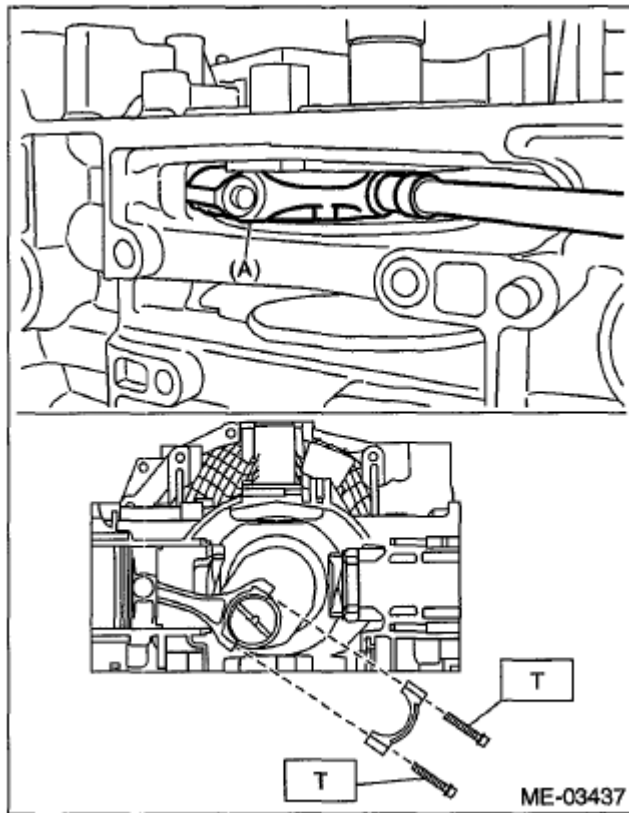
4. Using the ST, turn the crankshaft and match the positions of the crank pin and the large end of the connecting rod.

ST 18252AA000 CRANKSHAFT SOCKET

5. Install the connecting rod cap.

Tightening torque:

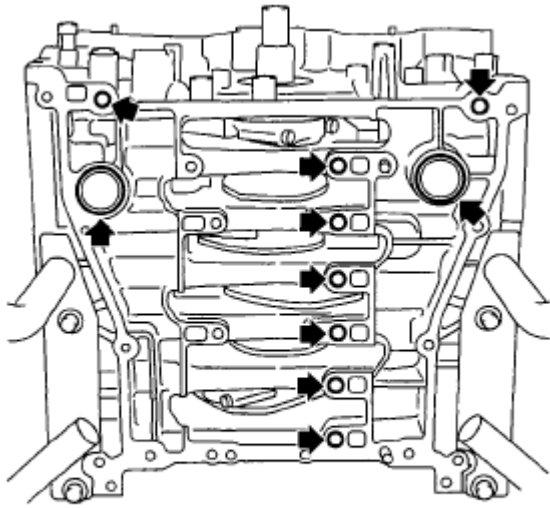
60 N.m (6.1 kgf-m, 44.3 ft-lb)



(A) #1 connecting rod

Fig. 240: Installing Connecting Rod Cap
Courtesy of SUBARU OF AMERICA, INC.

14. In the same procedures as for the #1 piston, install the piston and connecting rods to the cylinder block, in the order of #2, #3, #4, #5 and #6.
15. Install the O-ring to the underside of the cylinder block.



ME-03422

Fig. 241: Locating O-Rings To Underside Of Cylinder Block
Courtesy of SUBARU OF AMERICA, INC.

NOTE: Use new O-rings.

16. Apply liquid gasket to the mating surface of oil pan upper.

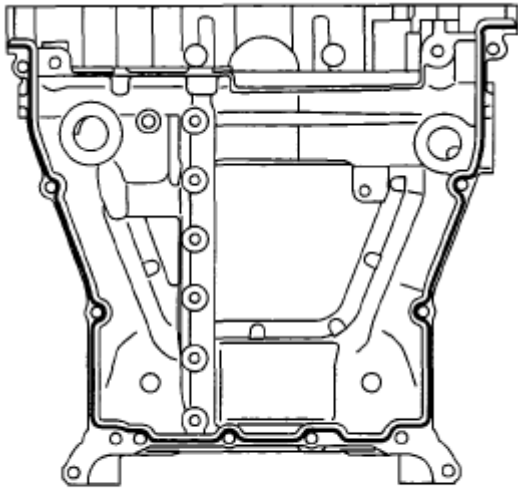
NOTE: Install within 5 min. after applying liquid gasket.

Liquid gasket:

THREE BOND 1217G (Part No. K0877Y0100) or equivalent

Liquid gasket applying diameter:

5.0±1.0 mm (0.20±0.04 in)



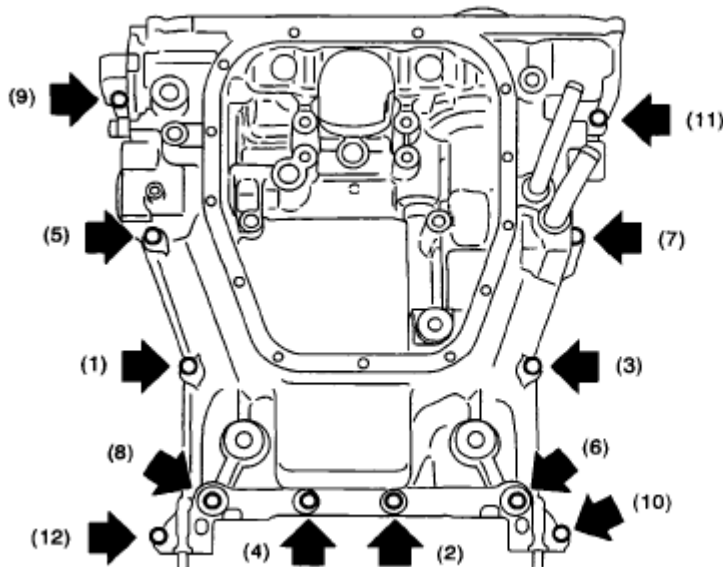
ME-03438

Fig. 242: Identifying Liquid Gasket Applying Area On Oil Pan Upper
Courtesy of SUBARU OF AMERICA, INC.

17. Temporarily tighten the oil pan upper.
18. Tighten the oil pan upper installing bolts in the numerical order as shown in the figure.

Tightening torque:

18 N.m (1.8 kgf-m, 13.3 ft-lb)



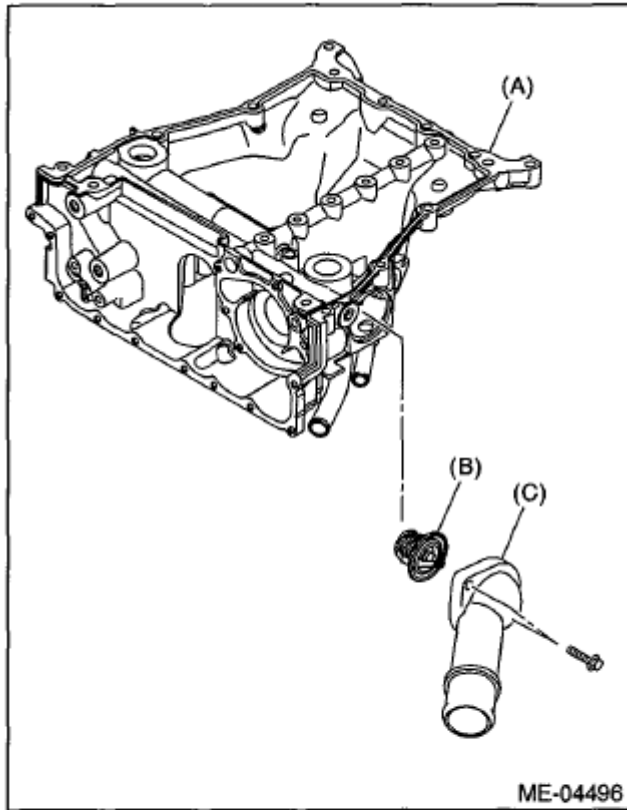
ME-03440

Fig. 243: Locating Oil Pan Upper Bolts In Tightening Order
Courtesy of SUBARU OF AMERICA, INC.

19. Install the thermostat and thermostat cover.

Tightening torque:

6.4 N.m (0.7 kgf-m, 4.7 ft-lb)



- (A) Oil pan upper
- (B) Thermostat
- (C) Thermostat cover

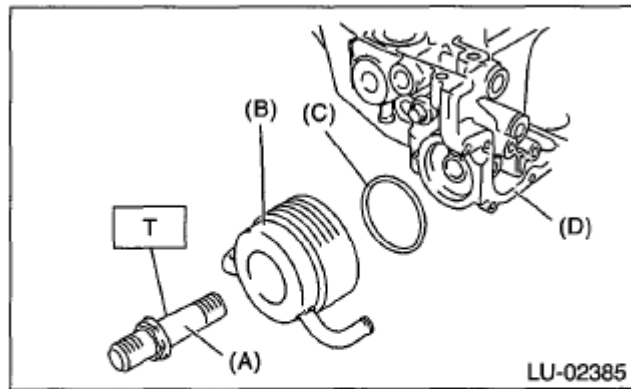
Fig. 244: Identifying Oil Pan Upper, Thermostat And Thermostat Cover
 Courtesy of SUBARU OF AMERICA, INC.

20. Install the oil level switch. Ref. to **INSTALLATION** , Oil Level Switch.
21. Install the oil pump. Ref. to **INSTALLATION** , Oil Pump.
22. Tighten the oil cooler connector to install the oil cooler to the oil pan upper.

Tightening torque:

54 N.m (5.5 kgf-m, 39.8 ft-lb)

NOTE: Use new O-rings.



- (A) Oil cooler connector
- (B) Oil cooler
- (C) O-ring
- (D) Oil pan upper

Fig. 245: Identifying Oil Cooler Connector, Oil Cooler, O-Ring And Oil Pan Upper
Courtesy of SUBARU OF AMERICA, INC.

23. Apply liquid gasket to the matching surface of oil pan lower.

NOTE: Install within 5 min. after applying liquid gasket.

Liquid gasket:

THREE BOND 1217G (Part No. K0877Y0100) or equivalent

Liquid gasket applying diameter:

5.0±1.0 mm (0.20±0.04 in)

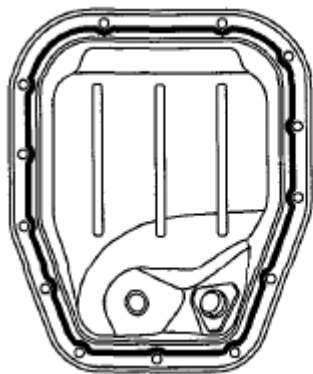


Fig. 246: Identifying Liquid Gasket Applying Area On Oil Pan Lower
Courtesy of SUBARU OF AMERICA, INC.

24. Tighten the oil pan lower installing bolts in the numerical order as shown in the figure.

Tightening torque:

6.4 N.m (0.7 kgf-m, 4.7 ft-lb)

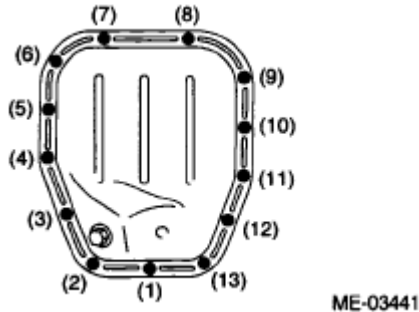


Fig. 247: Identifying Oil Pan Lower Bolts In Tightening Order
 Courtesy of SUBARU OF AMERICA, INC.

25. Install the crankshaft position sensor plate.

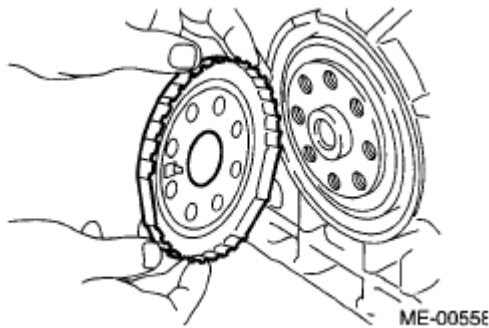


Fig. 248: Removing Crankshaft Position Sensor Plate
 Courtesy of SUBARU OF AMERICA, INC.

26. Install the crankshaft position sensor.

Tightening torque:

6.4 N.m (0.7 kgf-m, 4.7 ft-lb)

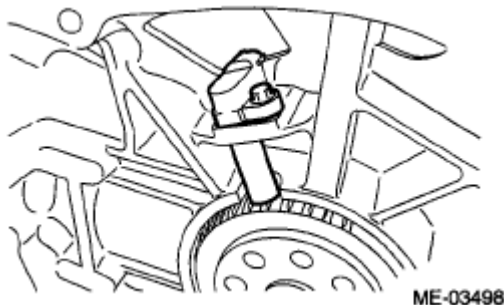


Fig. 249: Identifying Crankshaft Position Sensor
Courtesy of SUBARU OF AMERICA, INC.

27. Using the ST, install the drive plate.

ST 498497100 CRANKSHAFT STOPPER

Tightening torque:

90 N.m (9.2 kgf-m, 66.4 ft-lb)

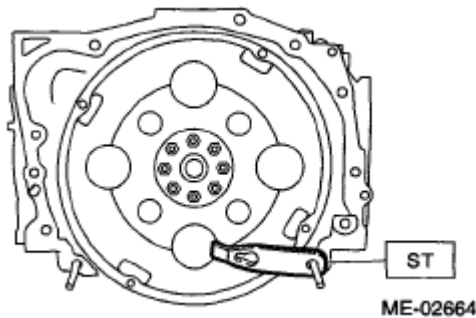
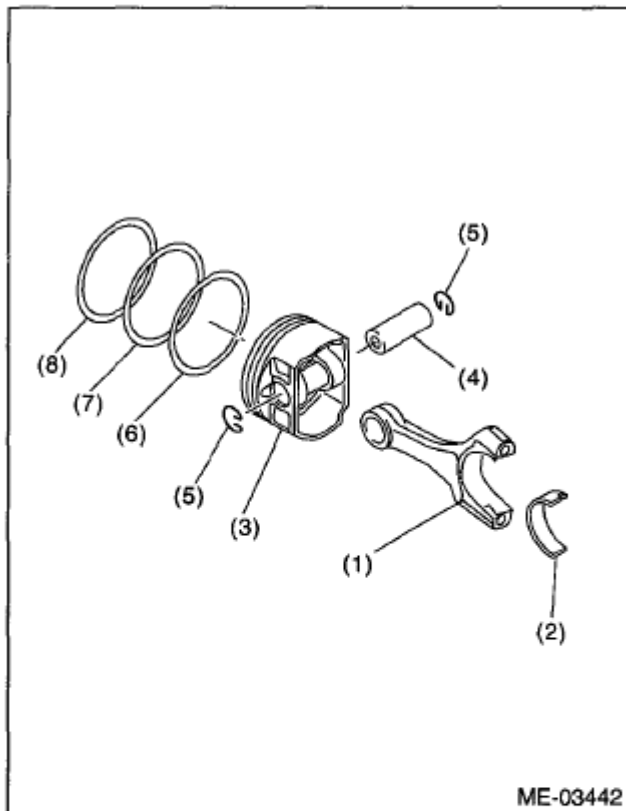


Fig. 250: Removing Drive Plate Using ST
Courtesy of SUBARU OF AMERICA, INC.

28. Install the cylinder head. Ref. to **INSTALLATION**, Cylinder Head.
29. Install the camshaft. Ref. to **INSTALLATION**, Camshaft.
30. Install the crank sprocket. Ref. to **INSTALLATION**, Crank Sprocket.
31. Install the cam sprocket. Ref. to **INSTALLATION**, Cam Sprocket.
32. Install the timing chain assembly. Ref. to **INSTALLATION**, Timing Chain Assembly.
33. Install the chain cover. Ref. to **INSTALLATION**, Chain Cover.
34. Install the crank pulley. Ref. to **INSTALLATION**, Crank Pulley.
35. Install the engine to the vehicle. Ref. to **INSTALLATION**, Engine Assembly.

DISASSEMBLY



- (1) Connecting rod
- (2) Connecting rod bearing
- (3) Piston
- (4) Piston pin
- (5) Snap ring
- (6) Oil ring
- (7) Second ring
- (8) Top ring

Fig. 251: Disassembled View Of Piston And Connecting Rod
 Courtesy of SUBARU OF AMERICA, INC.

NOTE: To prevent confusion of various parts, mark each part.

1. Remove the connecting rod bearing.
2. Remove the piston rings using piston ring expander.
3. Remove the oil ring by hand.

NOTE: Arrange the removed piston rings in proper order, to prevent confusion.

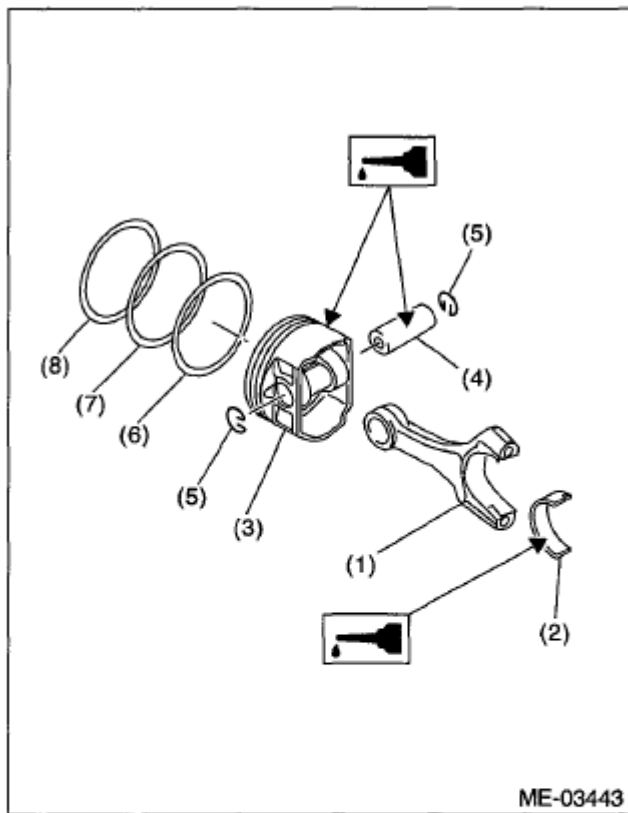
4. Remove the snap ring.
5. Using snap ring pliers, remove the snap ring.

6. Remove the piston pin from the piston.
7. Separate the piston and connecting rod.

NOTE: Mark the direction of front side to each connecting rod.

8. Remove the plug and orifice from the cylinder block as necessary. Ref. to **CYLINDER BLOCK, COMPONENT, General Description**.

ASSEMBLY



- (1) Connecting rod
- (2) Connecting rod bearing
- (3) Piston
- (4) Piston pin
- (5) Snap ring
- (6) Oil ring
- (7) Second ring
- (8) Top ring

Fig. 252: Assembled View Of Piston And Connecting Rod
 Courtesy of SUBARU OF AMERICA, INC.

1. Apply engine oil to the surface of the connecting rod bearing. Attach the connecting rod bearing to the connecting rod.
2. Join the connecting rod and piston.

NOTE: **Position each connecting rod with the marked side facing forward.**

3. Apply engine oil to the piston pin, and attach the piston pin.
4. Using snap ring pliers, attach the snap ring.
5. Install the oil ring upper rail, expander and lower rail by hand.
6. Install the second ring and top ring using piston ring expander.

INSPECTION

CYLINDER BLOCK

1. Visually check for cracks or damage. Use liquid penetrant tester on the important sections.
2. Check the oil passages for clogging.
3. Inspect the cylinder block surface that mates with cylinder head for warping by using a straight edge. If the warpage exceeds limit, replace the cylinder block.

Warping limit:

0.020 mm (0.0008 in)

Standard height of cylinder block:

202 mm (7.95 in)

2. CYLINDER AND PISTON

1. The cylinder bore size is stamped on the front upper face of the cylinder block.

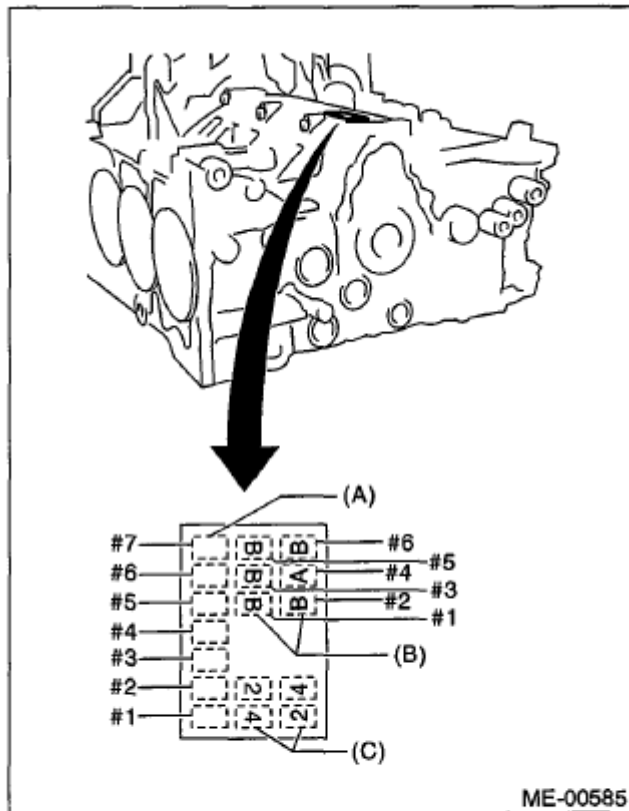
NOTE:

- **Measurement should be performed at a temperature of 20°C (68°F).**
- **Standard sized pistons are classified into two grades, "A" and "B". These grades should be used as guide lines in selecting a standard piston.**

Standard diameter:

A: 92.005 - 92.015 mm (3.6222 - 3.6226 in)

B: 91.995 - 92.005 mm (3.6218 - 3.6222 in)



- (A) Main journal size mark
- (B) Cylinder bore size mark
- (C) Cylinder block (RH) – (LH) combination mark

Fig. 253: Identifying Pistons Grades

Courtesy of SUBARU OF AMERICA, INC.

2. Measure inner diameter of each cylinder. Measure the inner diameter of each cylinder in both the thrust and piston pin directions at the heights as shown in the figure, using a cylinder bore gauge.

NOTE: Measurement should be performed at a temperature of 20°C (68°F).

Taper:

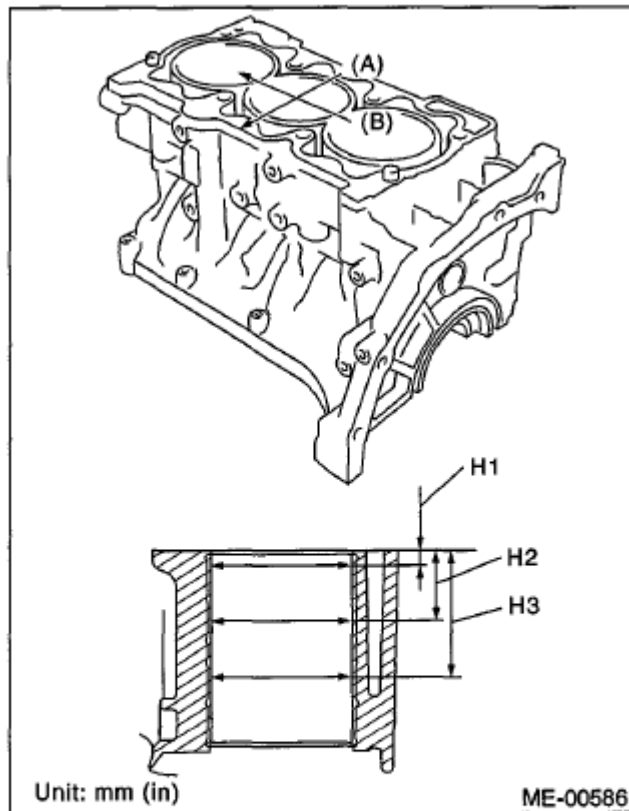
Standard

0.030 mm (0.0012 in)

Out-of-roundness:

Standard

0.010 mm (0.0004 in)



(A) Thrust direction

(B) Piston pin direction

H1: 10 mm (0.39 in)

H2: 45 mm (1.77 in)

H3: 80 mm (3.15 in)

Fig. 254: Identifying Inner Diameter Cylinder
Courtesy of SUBARU OF AMERICA, INC.

3. When the piston is to be replaced due to general or cylinder wear, select a suitable sized piston by measuring the piston clearance.
4. Measure outer diameter of each piston. Measure the outer diameter of each piston at the height as shown in the figure. (Thrust direction)

NOTE: Measurement should be performed at a temperature of 20°C (68°F).

Piston grade point H:

37.3 mm (1.4685 in)

Piston outer diameter:

Standard

A: 92.005 - 92.015 mm (3.6222 - 3.6226 in)

B: 91.995 - 92.005 mm (3.6218 - 3.6222 in)

0.25 mm (0.0098 in) oversize

92.245 - 92.265 mm (3.6317-3.6325 in)

0.50 mm (0.0197 in) oversize

92.495 - 92.515 mm (3.6415 - 3.6423 in)

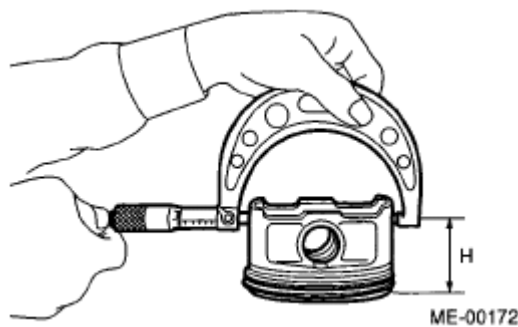


Fig. 255: Measuring Outer Diameter Of Piston
Courtesy of SUBARU OF AMERICA, INC.

5. Calculate the clearance between cylinder and piston.

NOTE: Measurement should be performed at a temperature of 20°C (68°F).

Cylinder to piston clearance at 20°C (68°F):

Standard

-0.010 - 0.010 mm (-0.0004 - 0.0004 in)

6. Boring and honing:

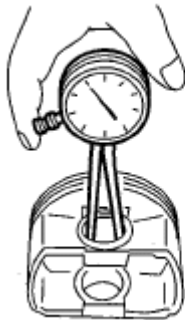
1. If any of the measured value of taper, out-of-roundness or cylinder-to-piston clearance is out of standard or if there is any damage on the cylinder wall, rebore it to replace with an oversize piston.

CAUTION: When any of the cylinders needs reboring, all other cylinders must be bored at the same time, and replaced with oversize pistons.

NOTE: Immediately after reboring, the cylinder diameter may differ from its real diameter due to temperature rise. Thus, when measuring the cylinder diameter, wait until it has cooled to room temperature.

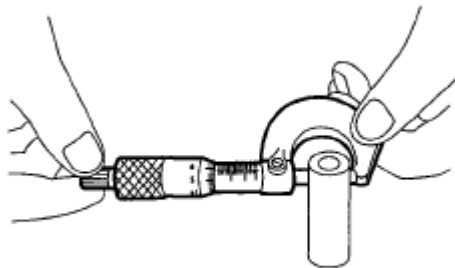
Cylinder inner diameter boring limit (diameter):***To 92.515 mm (3.6717 in)*****PISTON AND PISTON PIN**

1. Check the piston and piston pin for damage, cracks or wear. And check the piston ring groove for wear or damage. Replace if faulty.
2. Measure the clearance between piston and cylinder in each cylinder. Ref. to **CYLINDER AND PISTON**, INSPECTION, Cylinder Block. If the clearance exceeds the standard, replace the piston, or rebores the cylinder so that an oversize piston can be used.
3. Make sure the piston pin can be inserted into the piston pin hole by a thumb at 20°C (68°F). Replace if faulty.

Clearance between piston pin hole and piston pin:***Standard******0.004 - 0.008 mm (0.0002 - 0.0003 in)***

ME-00173

Fig. 256: Measuring Piston Pin Hole Diameter
Courtesy of SUBARU OF AMERICA, INC.

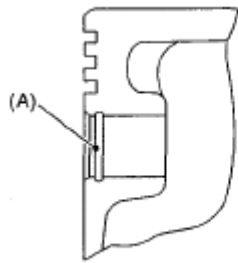


ME-00174

Fig. 257: Measuring Piston Pin Diameter
Courtesy of SUBARU OF AMERICA, INC.

4. Check the snap ring installation groove (A) on the piston for burr. If necessary, remove burr from the

groove so that the piston pin can lightly move.



ME-00175

Fig. 258: Identifying Circlip Installation Groove On Piston
Courtesy of SUBARU OF AMERICA, INC.

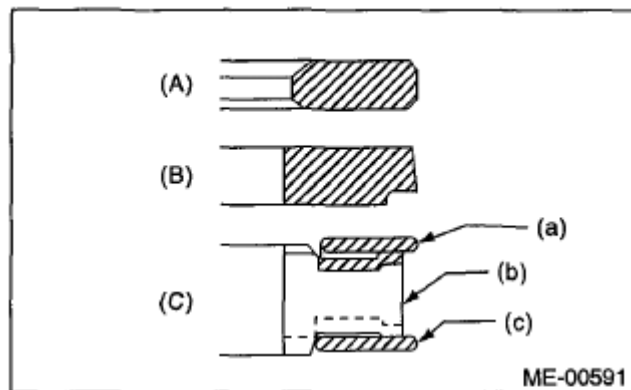
5. Check the piston pin snap ring for distortion, cracks and wear.

PISTON RING

1. If the piston ring is broken, damaged or worn, or if its tension is insufficient, or when the piston is replaced, replace the piston ring with a new part of the same size as piston.

NOTE:

- The top ring and second ring have the mark to determine the direction for installing. When attaching the ring to the piston, face these marks towards the top side.
- Oil ring consists of the upper rail, expander and lower rail. When installing to the piston, be careful of the direction of each rail.



ME-00591

- (A) Top ring
- (B) Second ring
- (C) Oil ring
- (a) Upper rail
- (b) Expander
- (c) Lower rail

Fig. 259: Identifying Piston Rings

Courtesy of SUBARU OF AMERICA, INC.

2. Squarely place the piston ring and oil ring in cylinder, and measure the piston ring gap with a thickness gauge.

PISTON RING SPECIFICATION CHART

		Standard mm (in)
Piston ring gap	Top ring	0.20 - 0.25 (0.0079 - 0.0098)
	Second ring	0.40 - 0.50 (0.0157 - 0.0197)
	Oil ring	0.20 - 0.50 (0.0079 - 0.0197)

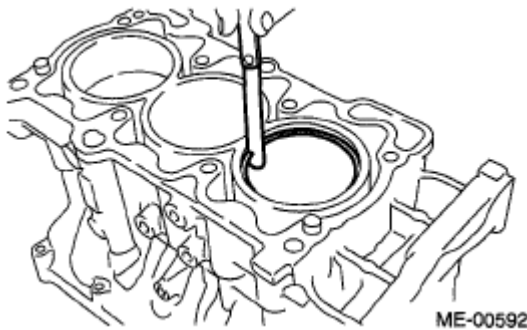


Fig. 260: Measuring Piston Ring Gap With Thickness Gauge
Courtesy of SUBARU OF AMERICA, INC.

3. Fit the piston ring straight into the piston ring groove, then measure the clearance between piston ring and piston ring groove with a thickness gauge.

NOTE: Before measuring the clearance, clean the piston ring groove and piston ring.

PISTON RING SPECIFICATION CHART

		Standard mm (in)
Clearance between piston ring and piston ring groove	Top ring	0.040 - 0.080 (0.0016 - 0.0031)
	Second ring	0.030 - 0.070 (0.0012 - 0.0028)
Clearance between oil ring and oil ring groove		0.065 - 0.165 (0.0026 - 0.0065)

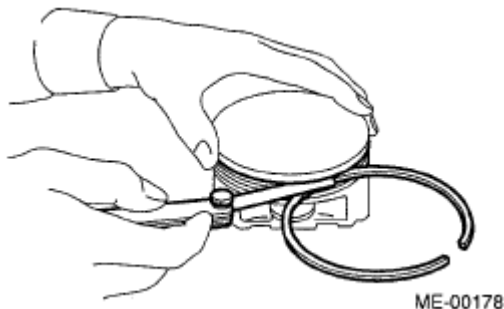


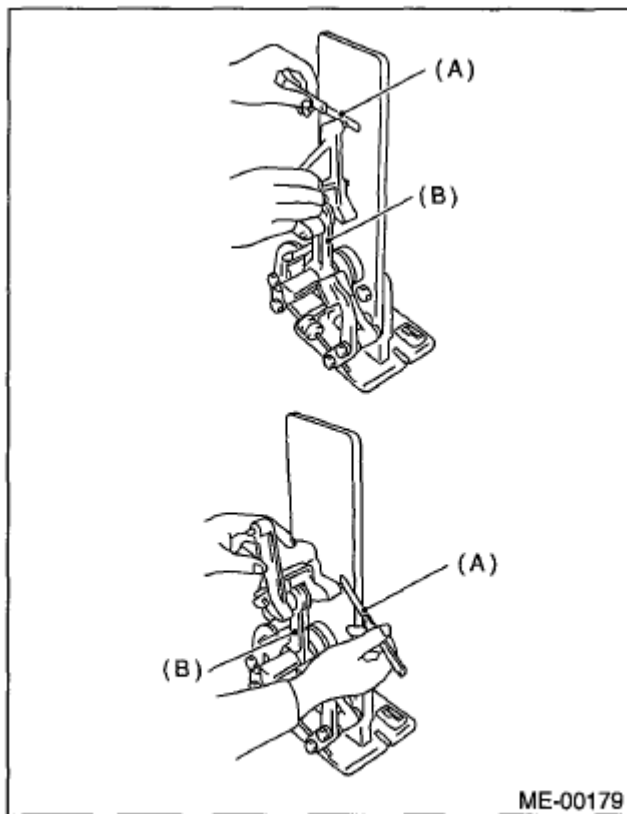
Fig. 261: Measuring Clearance Between Piston Ring And Piston Ring Groove
Courtesy of SUBARU OF AMERICA, INC.

CONNECTING ROD

1. Replace the connecting rod, if the large end thrust surface is damaged.
2. Check for bend or twist using a connecting rod aligner. Replace the connecting rod if it has the bend or twist.

Limit of bend or twist per 100 mm (3.94 in) in length:

0.10 mm (0.0039 in)



(A) Thickness gauge

(B) Connecting rod

Fig. 262: Checking Connecting Rod Bend
Courtesy of SUBARU OF AMERICA, INC.

3. Install the connecting rod with bearings attached to the crankshaft, and using a thickness gauge, measure the thrust clearance. If the thrust clearance exceeds the standard or uneven wear is found, replace the connecting rod.

Connecting rod thrust clearance:

Standard

0.070 - 0.330 mm (0.0028 - 0.0130 in)

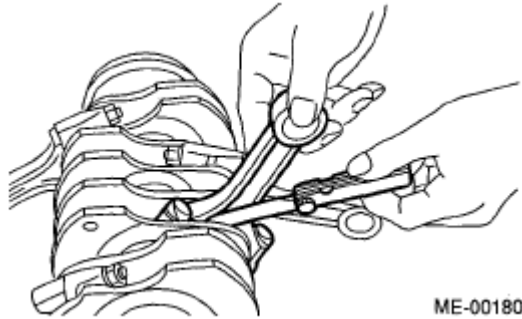


Fig. 263: Measuring Connecting Rod Side Clearance
Courtesy of SUBARU OF AMERICA, INC.

4. Inspect the connecting rod bearing for scar, peeling, seizure, melting, wear, etc.
5. Measure the oil clearance on each connecting rod bearing using plastigauge. If any oil clearance is not within the standard, replace the defective bearing with a new part of standard size or undersize as necessary. (See the table below.)

Connecting rod oil clearance:

Standard 0.016 - 0.043 mm (0.0006 - 0.0017 in)

CONNECTING ROD SPECIFICATION CHART

Unit: mm (in)		
Bearing	Bearing size (Thickness at center)	Outer diameter of crank pin
Standard	1.489-1.505 (0.0586 - 0.0593)	51.976 - 52.000 (2.0463 - 2.0472)
0.03 (0.0012) Undersize	1.507-1.515 (0.0593 - 0.0596)	51.954 - 51.970 (2.0454 - 2.0461)
0.05 (0.0020) Undersize	1.517-1.525 (0.0597 - 0.0600)	51.934 - 51.950 (2.0446-2.0453)
0.25 (0.0098) Undersize	1.617-1.625 (0.0637 - 0.0640)	51.734 - 51.750 (2.0368 - 2.0374)

6. Inspect the bushing at connecting rod small end, and replace with a new part if worn or damaged.
7. Measure the piston pin clearance at connecting rod small end. Replace it with a new part if the value is not within the standard,

Clearance between piston pin and bushing:

Standard

0 - 0.022 mm (0 - 0.0009 in)

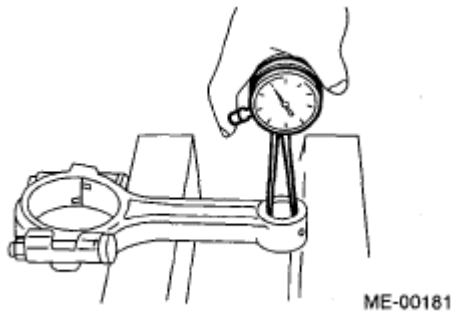


Fig. 264: Measuring Piston Pin Hole Diameter
Courtesy of SUBARU OF AMERICA, INC.

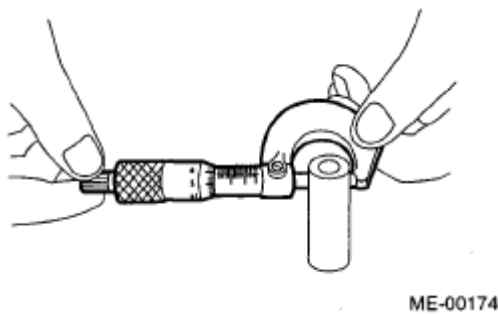


Fig. 265: Measuring Piston Pin Diameter
Courtesy of SUBARU OF AMERICA, INC.

8. The replacement procedure for the connecting rod small end bushing is as follows.
 1. Remove the bushing from connecting rod with ST and press.
 2. Apply oil on the periphery of the new bushing, and press the bushing in with the ST.

ST 18350AA000 CONNECTING ROD BUSHING REMOVER AND INSTALLER

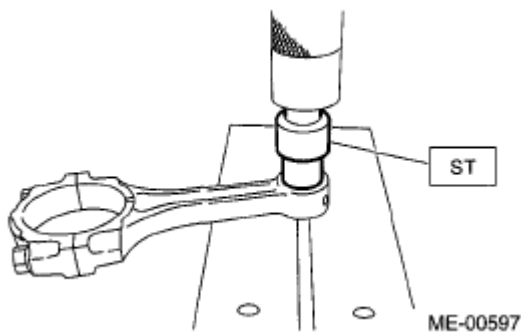


Fig. 266: Removing Bushing From Connecting Rod With ST
Courtesy of SUBARU OF AMERICA, INC.

3. Make two 3 mm (0.12 in) holes in the pressed bushing to match the pre-manufactured holes on the connecting rod, then ream the inside of the bushing.

4. After completion of reaming, clean the bushing to remove chips.

CRANKSHAFT AND CRANKSHAFT BEARING

1. Clean the crankshaft completely, and check it for cracks using liquid penetrant tester. If defective, replace the crankshaft.
2. Check the crankshaft for bend, and repair or replace if needed. If it exceeds the limit, correct or replace it.

NOTE: If a suitable V-block is not available, using the #1 and #7 crankshaft bearings on cylinder block, position the crankshaft on cylinder block. Then, measure the crankshaft bend using a dial gauge.

Crankshaft bend limit:

0.035 mm (0.0014 in)

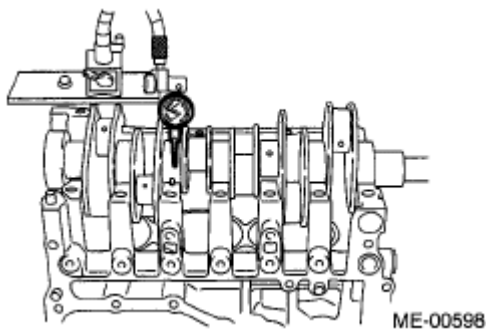


Fig. 267: Measuring Crankshaft Bend Using Dial Gauge
Courtesy of SUBARU OF AMERICA, INC.

3. Inspect the crank journal and crank pin for wear. If they are not within the standard, replace the bearing with a suitable (undersize) one, and replace or grind to correct the crankshaft as necessary. When grinding the crank journal or crank pin, finish them to the specified dimensions according to the undersize bearing to be used.

Crank pin:

Out-of-roundness

0.005 mm (0.0002 in)

Cylindricality

0.006 mm (0.0002 in)

Grinding limit (dia.)

To 51.734 mm (2.0368 in)

Crank journal:

Out-of-roundness

0.005 mm (0.0002 in)

Cylindricity

0.006 mm (0.0002 in)

Grinding limit (dia.)

To 63.742 mm (2.5095 in)



Fig. 268: Checking Crank Journal And Crank Pin Diameter
Courtesy of SUBARU OF AMERICA, INC.

CRANK JOURNAL SPECIFICATION CHART

		Unit: mm (in)		
		Crank journal diameter		
		#1, #3, #5	#7	#2, #4, #6
Standard	Journal O.D.	63.992 - 64.016 (2.5194 - 2.5203)		
	Bearing size (Thickness at center)	1.996 - 2.013 (0.0786 - 0.0793)	1.992 - 2.009 (0.0784 - 0.0791)	1.996 - 2.013 (0.0786 - 0.0793)
0.03 (0.0012) Undersize	Journal O.D.	63.962 - 63.978 (2.5182 - 2.5188)		
	Bearing size (Thickness at center)	2.011 - 2.014 (0.0792 - 0.0793)	2.011 - 2.014 (0.0792 - 0.0793)	2.015 - 2.018 (0.0793 - 0.0794)
0.05 (0.0020) Undersize	Journal O.D.	63.942 - 63.958 (2.5174 - 2.5180)		
	Bearing size (Thickness at center)	2.021 - 2.024 (0.0796 - 0.0797)	2.021 - 2.024 (0.0796 - 0.0797)	2.025 - 2.028 (0.0797 - 0.0798)
		51.734 - 51.750		

	Journal O.D.	63.742 - 63.758 (2.5095 - 2.5102)			(2.0368 - 2.0374)
0.25 (0.0098) Undersize	Bearing size (Thickness at center)	2.121-2.124 (0.0835 - 0.0836)	2.121-2.124 (0.0835 - 0.0836)	2.125 - 2.128 (0.0837 - 0.0838)	1.617-1.625 (0.0637 - 0.0640)

- Use a thickness gauge to measure the thrust clearance of crankshaft at center bearing. If clearance exceeds the standard, replace the bearing.

Crankshaft thrust clearance:

Standard

0.030 - 0.115 mm (0.0012 - 0.0045 in)

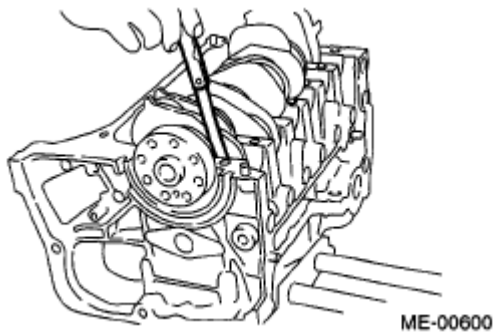


Fig. 269: Measuring Thrust Clearance Of Crankshaft
Courtesy of SUBARU OF AMERICA, INC.

- Inspect individual crankshaft bearings for signs of flaking, seizure, melting and wear.
- Measure the oil clearance on each crankshaft bearing using plastigauge. If the measured value is out of standard, replace the defective bearing with an undersize one, and replace or grind to correct the crankshaft as necessary.

Crankshaft oil clearance:

Standard

0.010 - 0.030 mm (0.0004 - 0.0012 in)

OIL FLOW CONTROL SOLENOID VALVE

REMOVAL

Specifications for the oil flow control solenoid valve are included in the FU section. Ref. to **REMOVAL** , Oil Flow Control Solenoid Valve.

INSTALLATION

Specifications for the oil flow control solenoid valve are included in the FU section. Ref. to **INSTALLATION**, Oil Flow Control Solenoid Valve.

INTAKE AND EXHAUST VALVE

SPECIFICATION

Refer to "Cylinder Head" for removal and installation procedures of the intake and exhaust valves. Ref. to **REMOVAL**, Cylinder Head. Ref. to **INSTALLATION**, Cylinder Head.

PISTON

SPECIFICATION

Refer to "Cylinder Block" for removal and installation procedures of pistons. Ref. to **REMOVAL**, Cylinder Block. Ref. to **INSTALLATION**, Cylinder Block.

CONNECTING ROD

SPECIFICATION

Refer to "Cylinder Block" for removal and installation procedures of connecting rods. Ref. to **REMOVAL**, Cylinder Block. Ref. to **INSTALLATION**, Cylinder Block.

CRANKSHAFT

SPECIFICATION

Refer to "Cylinder Block" for removal and installation procedures of the crankshaft. Ref. to **REMOVAL**, Cylinder Block. Ref. to **INSTALLATION**, Cylinder Block.

ENGINE TROUBLE IN GENERAL

INSPECTION

NOTE: The "RANK" shown in the chart shows the possibilities of the cause of trouble in order from "Very often" to "Rarely".

A - Very often

B - Sometimes

C - Rarely

ENGINE TROUBLE INSPECTION CHART

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2010 Subaru Outback R

2010 ENGINE Mechanical (H6DO) - Legacy and Outback

Symptoms	Problem parts etc.	Possible cause	RANK
1. Engine does not start.			
1) Starter does not turn.	Starter	Defective battery-to-starter harness	B
		Defective starter switch	C
		Defective inhibitor switch	C
		Defective starter	B
	Battery	Improper connection of terminal	A
		Run-down battery	A
		Defective charging system	B
	Friction	Seizure of crankshaft and connecting rod bearing	C
		Seized camshaft	C
		Seized or stuck piston and cylinder	C
2) Initial combustion does not occur.	Starter	Defective starter	C
	Engine control system Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
	Fuel line	Defective fuel pump and relay	A
		Clogged fuel line	C
		Lack of fuel or insufficient fuel	B
	Timing chain	Trouble	B
		Defective timing	B
	Compression	Incorrect valve clearance	C
		Loosened spark plug or defective gasket	C
		Loosened cylinder head bolt or defective gasket	C
		Improper valve sealing	C
		Defective valve stem	C
		Worn or broken valve spring	B
		Worn or stuck piston rings, cylinder and piston	C
		Incorrect valve timing	B
		Improper engine oil (low viscosity)	B
	Engine control system Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
	Intake system	Defective intake manifold gasket	B
		Defective throttle body gasket	B
	Fuel line	Defective fuel pump and relay	C
		Clogged fuel line	C
		Lack of fuel or insufficient fuel	B
	Timing chain	Trouble	B
		Defective timing	B

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3) Initial combustion occurs.	Compression	Incorrect valve clearance	C
		Loosened spark plug or defective gasket	C
		Loosened cylinder head bolt or defective gasket	C
		Improper valve sealing	C
		Defective valve stem	C
		Worn or broken valve spring	B
		Worn or stuck piston rings, cylinder and piston	C
		Incorrect valve timing	B
		Improper engine oil (low viscosity)	B
4) Engine stalls after initial combustion.	Engine control system Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
	Intake system	Loosened or cracked intake duct	B
		Loosened or cracked PCV hose	C
		Loosened or cracked vacuum hose	C
		Defective intake manifold gasket	B
		Defective throttle body gasket	B
		Dirty air cleaner element	C
	Fuel line	Clogged fuel line	C
		Lack of fuel or insufficient fuel	B
	Timing chain	Trouble	B
		Defective timing	B
	Compression	Incorrect valve clearance	C
		Loosened spark plug or defective gasket	C
		Loosened cylinder head bolt or defective gasket	C
		Improper valve sealing	C
		Defective valve stem	C
		Worn or broken valve spring	B
		Worn or stuck piston rings, cylinder and piston	C
		Incorrect valve timing	B
		Improper engine oil (low viscosity)	B
	Engine control system Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
	Intake system	Loosened or cracked intake duct	A
		Loosened or cracked PCV hose	A
		Loosened or cracked vacuum hose	A
		Defective intake manifold gasket	B
		Defective throttle body gasket	B
		Defective PCV valve	C

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2. Rough idle and engine stall		Loosened oil filler cap	B
		Dirty air cleaner element	C
	Fuel line	Defective fuel pump and relay	C
		Clogged fuel line	C
		Lack of fuel or insufficient fuel	B
	Timing chain	Defective timing	C
	Compression	Incorrect valve clearance	B
		Loosened spark plug or defective gasket	B
		Loosened cylinder head bolt or defective gasket	B
		Improper valve sealing	B
		Defective valve stem	C
		Worn or broken valve spring	B
		Worn or stuck piston rings, cylinder and piston	B
		Incorrect valve timing	A
		Improper engine oil (low viscosity)	B
	Lubrication system	Incorrect oil pressure	B
		Defective rocker cover gasket	C
	Cooling system	Over-heating	C
	Others	Evaporative emission control system malfunction	A
		Stuck or damaged throttle valve	B
3. Low output, hesitation and poor acceleration	Engine control system Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
	Intake system	Loosened or cracked intake duct	A
		Loosened or cracked PCV hose	A
		Loosened or cracked vacuum hose	B
		Defective intake manifold gasket	B
		Defective throttle body gasket	B
		Defective PCV valve	B
		Loosened oil filler cap	B
		Dirty air cleaner element	A
	Fuel line	Defective fuel pump and relay	B
		Clogged fuel line	B
		Lack of fuel or insufficient fuel	C
	Timing chain	Defective timing	B
		Incorrect valve clearance	B
		Loosened spark plug or defective gasket	B
		Loosened cylinder head bolt or defective gasket	B
		Improper valve sealing	B

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	Compression	Defective valve stem	C
		Worn or broken valve spring	B
		Worn or stuck piston rings, cylinder and piston	C
		Incorrect valve timing	A
		Improper engine oil (low viscosity)	B
	Lubrication system	Incorrect oil pressure	B
		Defective rocker cover gasket	C
	Cooling system	Over-heating	C
		Over-cooling	C
	Others	Evaporative emission control system malfunction	A
4. Surging	Engine control system Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
	Intake system	Loosened or cracked intake duct	A
		Loosened or cracked PCV hose	A
		Loosened or cracked vacuum hose	A
		Defective intake manifold gasket	B
		Defective throttle body gasket	B
		Defective PCV valve	B
		Loosened oil filler cap	B
		Dirty air cleaner element	B
	Fuel line	Defective fuel pump and relay	B
		Clogged fuel line	B
		Lack of fuel or insufficient fuel	C
	Timing chain	Defective timing	B
	Compression	Incorrect valve clearance	B
		Loosened spark plug or defective gasket	C
		Loosened cylinder head bolt or defective gasket	C
		Improper valve sealing	C
		Defective valve stem	C
		Worn or broken valve spring	C
		Worn or stuck piston rings, cylinder and piston	C
		Incorrect valve timing	A
		Improper engine oil (low viscosity)	B
	Cooling system	Over-heating	B
	Others	Evaporative emission control system malfunction	C
5. Engine does not return to idle.		Engine control system Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> .	A

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	Intake system	Loosened or cracked vacuum hose	A
	Others	Stuck or damaged throttle valve	A
6. Dieseling (Run-on)	Engine control system Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
	Cooling system	Over-heating	B
	Others	Evaporative emission control system malfunction	B
7. After burning in exhaust system	Engine control system Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
	Intake system	Loosened or cracked intake duct	C
		Loosened or cracked PCV hose	C
		Loosened or cracked vacuum hose	B
		Defective PCV valve	B
		Loosened oil filler cap	C
	Timing chain	Defective timing	B
	Compression	Incorrect valve clearance	B
		Loosened spark plug or defective gasket	C
		Loosened cylinder head bolt or defective gasket	C
		Improper valve sealing	B
		Defective valve stem	C
		Worn or broken valve spring	C
		Worn or stuck piston rings, cylinder and piston	C
		incorrect valve timing	A
	Lubrication system	Incorrect oil pressure	C
	Cooling system	Over-cooling	C
	Others	Evaporative emission control system malfunction	C
8. Knocking	Engine control system Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
	Intake system	Loosened oil filler cap	B
	Timing chain	Defective timing	B
	Compression	Incorrect valve clearance	C
		Incorrect valve timing	B
	Cooling system	Over-heating	A
	Intake system	Loosened or cracked PCV hose	A
		Defective PCV valve	B
		Loosened oil filler cap	C
	Compression	Defective valve stem	A
		Worn or stuck piston rings, cylinder and	A

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9. Excessive engine oil consumption	Lubrication system	piston	
		Loosened oil pump attaching bolts and defective gasket	B
		Defective oil filter O-ring	B
		Defective crankshaft oil seal	B
		Defective rocker cover gasket	B
		Loosened oil drain plug or defective gasket	B
		Loosened oil pan fitting bolts or defective oil pan	B
10. Excessive fuel consumption	Engine control system Ref. to <u>BASIC DIAGNOSTIC PROCEDURE</u> .		A
	Intake system	Dirty air cleaner element	A
	Timing chain	Defective timing	B
	Compression	Incorrect valve clearance	B
		Loosened spark plug or defective gasket	C
		Loosened cylinder head bolt or defective gasket	C
		Improper valve sealing	B
		Defective valve stem	C
		Worn or broken valve spring	C
		Worn or stuck piston rings, cylinder and piston	B
		Incorrect valve timing	B
	Lubrication system	Incorrect oil pressure	C
	Cooling system	Over-cooling	C

ENGINE NOISE

INSPECTION

ENGINE NOISE INSPECTION CHART

Type of sound	Condition	Possible cause
Regular clicking sound	Sound increases as engine speed increases.	- Valve mechanism is defective. - Incorrect valve clearance - Worn camshaft - Broken valve spring - Trouble of valve lifter
	Oil pressure is low.	- Worn camshaft main bearing - Worn connecting rod bearing

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Heavy and dull clank	Oil pressure is normal.	(large end) Damaged front mount
High-pitched clank	Sound is noticeable when accelerating with an overload condition.	• Ignition timing advanced • Accumulation of carbon inside combustion chamber • Wrong heat range of spark plug • Improper octane value gasoline
Clank when engine speed is between 1,000 and 2,000 RPM.	Noise is reduced when fuel injector connector of noisy cylinder is disconnected. ⁽¹⁾	• Worn crankshaft main bearing • Worn connecting rod bearing (large end)
Knocking sound when engine is operating under idling speed and engine is warm	Noise is reduced when fuel injector connector of noisy cylinder is disconnected. ⁽¹⁾	• Worn cylinder liner and piston ring • Broken or stuck piston ring • Worn piston pin and hole at piston end of connecting rod
	Sound is not reduced if each fuel injector connector is disconnected in turn. ⁽¹⁾	• Unusually worn valve lifter • Worn cam gear • Worn camshaft journal bore in cylinder head
Squeaky sound	-	Insufficient generator lubrication
Rubbing sound	-	Poor contact of generator brush and rotor
Gear scream when starting engine	-	• Defective ignition starter switch • Worn gear and starter pinion
Sound like polishing glass with a dry cloth	-	• V-belt • Defective water pump shaft
Hissing sound	-	• Insufficient compression • Air leakage in air intake system, hose, connection or manifold
Timing chain noise	-	• Loose timing chain • Timing chain contacting with adjacent part
Valve lifter noise	-	Incorrect valve clearance

(1) When disconnecting the fuel injector connector, the malfunction indicator light illuminates and DTC is stored in ECM memory. Therefore, perform the Clear Memory Mode Ref. to **OPERATION**, Clear Memory Mode. and Inspection Mode Ref. to **PROCEDURE**, Inspection Mode. after

connecting the fuel injector connector.